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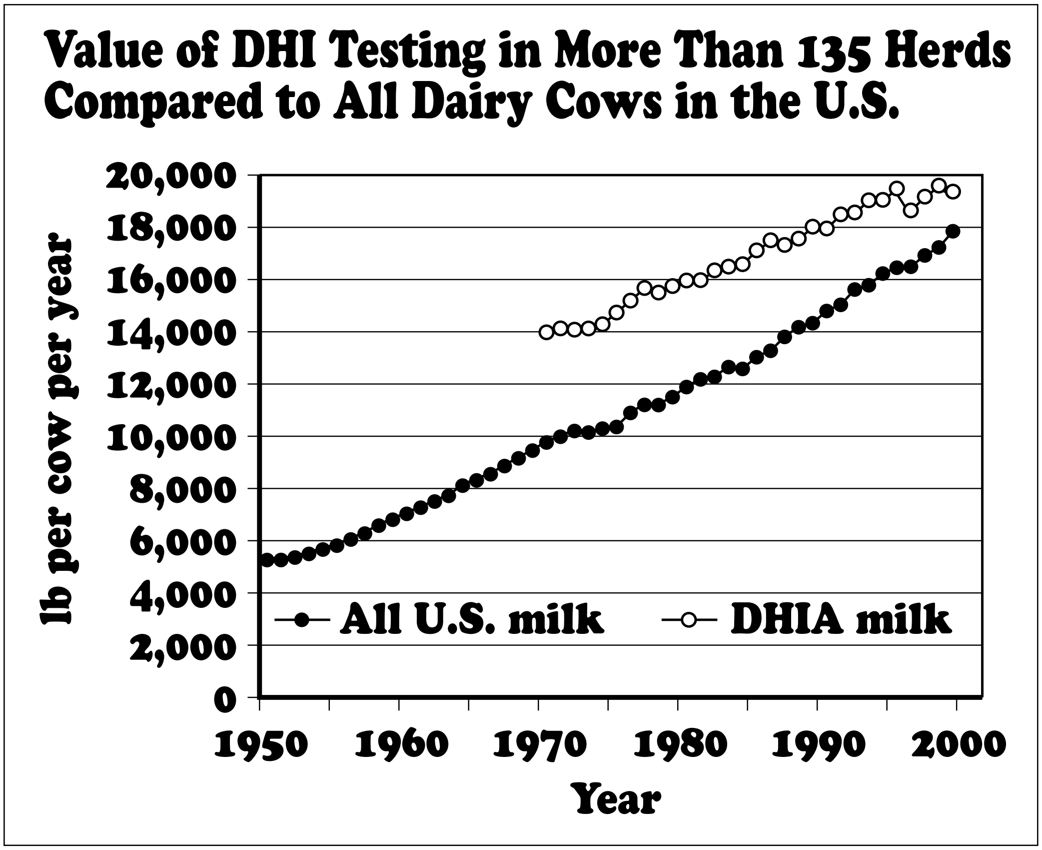

DAIRY DAY 2001

Report of Progress 881

2001 Dairy Day Program

Hutchinson (Whiteside)
November 8

10:00 Registration

10:20 Welcome

10:30 Research Updates
Dr. Stevenson "Reproduction"
Dr. Harner "Drinking Water"

11:00 Featured Speaker: Dr. Bill Mahanna
Pioneer Hi-Bred International, Inc.
"Selecting Silage Hybrids"

12:00 Lunch/Dinner--Courtesy of the Kansas Dairy Association (KDA)

13:00 Dr. Bill Mahanna
"Evaluating Nutritive Value of Silages"

13:30 Research Updates
Dr. Smith "Fan Placement in Barns"
Dr. Brouk "Headlocks vs. Feed Rails"
Dr. Shirley "Nutrition"

14:00 Adjourn

Seneca (Valentino's)
November 9

10:00 Registration

10:20 Welcome

10:30 Research Updates
Dr. Smith "Fan Placement in Barns"
Dr. Brouk "Headlocks vs. Feed Rails"
Dr. Shirley "Nutrition"

11:00 Featured Speaker: Dr. Bill Mahanna
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12:00 Lunch/Dinner--Courtesy of the Kansas Dairy Association (KDA)

13:00 Dr. Bill Mahanna
"Evaluating Nutritive Value of Silages"

13:30 Research Updates
Dr. Schmidt "Raw Milk Quality"
Dr. Harner "Drinking Water"
Dr. Stevenson "Reproduction"

14:00 Adjourn

FOREWORD

Members of the Dairy Commodity Group of the Department of Animal Sciences and Industry are pleased to present this Report of Progress, 2001. Dairying continues to be a viable business and contributes significantly to the agricultural economy of Kansas. In 1999, dairy farms accounted for 2.5% of all farm receipts, ranking 7th overall among all Kansas farm commodities. Wide variation exists in the productivity per cow as indicated by the production testing program (Heart of America Dairy Herd Improvement Association [DHIA]). The Heart of America DHIA opened for business on January 1, 1995, by combining three labs into one. More than 122,000 cows were enrolled in the DHI program from Kansas, Nebraska, Oklahoma, Arkansas, North Dakota, and South Dakota beginning January 1, 2001. A comparison of Kansas DHIA cows with all those in the Heart of America DHIA program for the year 2000 is illustrated in the table below.

Comparison of Heart of America Cows with Kansas Cows - 2000

Item	HOA	KS
No. of herds	1,056	326
No. of cows/herd	113	106
Milk, lb	19,717	20,252
Fat, lb	724	744
Protein, lb	631	640
IOFC*, $	1,352	1,293
Milk price, $	11.79	11.48

*IOFC = income over feed costs

Most of this success occurs because of better management of what is measured in monthly DHI records. Continued emphasis should be placed on furthering the DHI program and encouraging use of its records in making management decisions. In addition, use of superior, proven sires in artificial insemination (AI) programs shows average predicted transmitting ability (PTA) for milk of all 299 Holstein AI bulls in service (August, 2001) to be +1,479 lb (range of +449 to +2,740 lb). Emphasis on incorporation of superior genetics through greater use of AI sires is warranted.

The excellent functioning of the Dairy Teaching and Research Center (DTRC) is due to the special dedication of our staff. It has served us well for more than 24 years. We acknowledge our current DTRC staff for their dedication: Michael V. Scheffel (Manager); Donald L. Thiemann; Daniel J. Umsheid; William P. Jackson; Charlotte Boger; Lesa Reves; and Robert Reves. Special thanks are given to Betty A. Hensley and Cheryl K. Armendariz and a host of graduate and undergraduate students for their technical assistance in our laboratories and at the DTRC.

Each dollar spent for research yields a 30 to 50% return in practical application. Research is not only tedious and painstakingly slow but expensive. Those interested in supporting dairy research are encouraged to consider participation in the Livestock & Meat Industry Council, Inc. (LMIC), a philanthropic organization dedicated to furthering academic and research pursuits by the Department of Animal Sciences and Industry (more details about the LMIC are found at the end of this publication).

J. S. Stevenson, Editor
2001 Dairy Day Report of Progress

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EVALUATION OF HEAT STRESS IN 4- AND 6-ROW FREESTALL BUILDINGS LOCATED IN NORTHWEST IOWA

J. F. Smith, M. J. Brouk, and J. P. Harner [1]

Summary

A trial was conducted in the summer of 2000 to evaluate the effect of 4- and 6-row freestall barns located in northwest Iowa on barn temperature, barn humidity, and respiration rates of lactating Holstein cows. Temperature, temperature-humidity index (THI), and respiration rates were greater in 6-row than 4-row freestall barns. Respiration rates were greater in 6-row versus 4-row buildings. The magnitude of difference in the temperature and THI variables may not explain the differences detected in respiration rates. It is possible that a relationship between animal density and social interaction could increase respiration rates when animal density is increased. It may also be possible that the level of mechanical ventilation required to keep cows comfortable in 6-row barns may be greater.

(Key Words: Heat Stress, Freestalls, Cow Comfort.)

Introduction

Animal density is increased when lactating dairy cows are housed in 6-row freestall buildings. Concerns have been raised that the level of heat stress is greater in 6-row than 4-row freestall buildings. A trial was conducted during the summer of 2000 to evaluate the effect of 4- and 6-row freestall barns located in northwest Iowa on barn temperature, barn humidity, and respiration rates of lactating Holstein cows.

Procedures

Six freestall barns (3, 6-row and 3, 4-row) on five farms were sampled. Temperature and humidity readings were collected every 15 minutes at four locations in each barn. Ambient temperature and humidity were collected at two locations in close proximity to each freestall barn. All temperature and humidity data were collected using HOBO data loggers programmed to collect data every 15 min, 24 hr per day. Temperature and humidity data were collected continuously from June 9, 2000 until September 27, 2000. Respiration rates were collected in the morning between 6 and 8 and in the afternoon between 2 and 4 on three different days. During each observation period respiration rates were collected from 50 cows in each barn.

Results

Average temperature, humidity, and THI in 4-row and 6-row barns during the 3 days when respiration rates were collected are listed in Table 1. Table 1 also contains average ambient temperature, relative humidity, and THI along with the deviations from these ambient variables for 4- and 6-row barns. Average temperature and THI were greater ($P<0.05$) in 6-row barns during the period when respiration rates were measured. There are also differences ($P<0.05$) in ambient relative humidity and THI between the locations of 4- and 6-row barns. Statistical differences associated with temperature and humidity between 4- and 6-row

[1]Department of Biological and Agricultural Engineering.

barns exist; however, numerically these differences are minimal and may not be biologically significant.

In Table 2 the average respiration rates, THI, temperatures and relative humidity are presented for morning and afternoon observations for each barn type. Respiration rates were greater (*P*<0.05) in the morning and afternoon in 6-row barns than in 4-row barns.

Average morning and afternoon respiration rates are presented in Table 3. Respiration rates by day of observation are presented in Table 4.

Conclusions

Temperature, relative humidity, and THI were greater in 6-row than 4-row freestall barns compared to ambient conditions. Respiration rates of cows were greater in 6-row than 4-row buildings.

The magnitude of difference in the temperature and humidity variables do not account for the differences detected in respiration rates. It is possible that a relationship between cow density and social interaction could increase respiration rates when cow density is increased. It also may be possible that the level of mechanical ventilation required to keep cows comfortable in 6-row barns may be greater.

Table 1. Average Temperature, Relative Humidity and THI of 4-Row and 6-Row Barns for Three Days

Variable	4-Row	6-Row	Effect of Barn
Barn temperature	74.1	74.4	0.03
Barn relative humidity	76.3	76.1	0.44
Barn THI	71.6	71.9	0.01
Ambient temperature	73.2	73.0	0.08
Ambient relative humidity	79.1	78.2	0.01
Ambient THI	70.9	70.7	0.05
Difference Between Ambient and Barn Conditions			
Temperature	+1.0	+1.4	0.01
Relative humidity	−2.8	−2.1	0.01
THI	+0.7	+1.2	0.01

Table 2. Average Morning and Afternoon Temperature, Humidity, and THI during Respiration Measurements for 4-Row and 6-Row Freestall Barns

	Barn Type				
	4-Row		6-Row		Effect of barn
Item	AM	PM	AM	PM	(*P* value)
Barn temperature, °F	68.2	79.9	68.9	80.0	0.22
Barn relative humidity, %	88.4	62.1	87.1	61.8	0.27
Barn THI	67.6	75.3	68.2	75.3	0.18
Ambient temperature, °F	66.6	79.4	66.5	80.0	0.44
Ambient relative humidity, %	93.7	63.3	91.5	60.7	0.01
Ambient THI	66.3	74.9	66.2	75.1	0.96
Differences Between Ambient and Barn Conditions					
Temperature, °F	+1.6	+0.5	+2.4	0.0	0.49
Relative humidity, %	−5.4	−1.2	−4.4	1.1	0.01
THI	+1.2	+0.3	+2.0	.2	0.06

Table 3. Average Morning and Afternoon Respiration Rates of Cows Housed in 4-Row and 6-Row Freestall Barns

Barn type	Morning	Afternoon	Average
	----------------------breaths per minute	-------------------------	
4-Row	60.5[a]	73.8[a]	67.2[a]
6-Row	65.8[b]	78.4[b]	72.1[b]

[a,b]Means within the same column differ $P<0.05$.

Table 4. Afternoon Respiration Rates, Barn Temperature, Relative Humidity and THI at Time of Respiration Measurements

	Barn Style					
	4-Row			6-Row		
	-------------- Day -----------			-------------- Day ----------		
	1	2	3	1	2	3
Afternoon respiration	82.1	71.4	68.0	91.1	76.4	67.6
Barn temperature	87.1	78.6	74.0	86.4	79.1	74.4
Humidity	61.3	58.3	66.7	63.0	55.7	66.7
THI	80.9	73.9	71.0	80.6	74.0	71.3

EFFECT OF FAN PLACEMENT ON MILK PRODUCTION AND DRY MATTER INTAKE OF LACTATING DAIRY COWS HOUSED IN A 4-ROW FREESTALL BARN

M. J. Brouk, J. F. Smith,
J. P. Harner [1] and S. E. DeFrain

Summary

Heat stress reduces milk production, feed intake, and reproductive efficiency each summer in Kansas. Without heat abatement procedures, milk production may decline 20-30% during the summer months. Research has shown that supplemental fan cooling in combination with low pressure feedline sprinklers can reduce the effects of heat stress on milk production and feed intake. One critical issue in heat stress abatement is the location of fans in a 4-row freestall barn. Research conducted during the summer of 2000 on a northeast Kansas dairy found that locating fans over both the feedline and head-to-head freestalls increased milk production 5.8 lb/cow/d and reduced respiration rates in the morning and at night compared to mounting fans only over the feedline. Pen feed intakes also tended to be greater when fans were located in both areas. Economic analysis showed that after accounting for cost associated with ownership, operation, and increased feed intake, net farm income was estimated to be increased by $3,600-6,600 for a pen of 84 cows. A 100-cow Kansas dairy could increase farm profits by $8,000 if these heat abatement techniques were utilized. Location of fans over both the feedline and freestalls in combination with a low pressure feedline sprinkling system is an effective heat stress abatement strategy in 4-row freestall barns.

(Key Words: Heat Stress, Cow Comfort, Cow Cooling.)

Introduction

Heat stress abatement in freestall barns should be a major concern for dairy producers and dairy industry advisors. Under modern management systems, lactating dairy cows may spend over 90% of the day in the freestall barn. Without effective freestall cooling systems, significant production and reproduction losses will occur. In terms of cow comfort, the effective temperature is a function of air temperature, humidity, air flow, and solar radiation. Heat dissipation from the dairy cow at temperatures above 60°F is largely due to evaporative losses from the skin with a much smaller portion lost via lung cooling. Thus, the goal of heat stress abatement in freestall barns should be to provide protection from solar radiation and maximize evaporative losses from the skin. Heat dissipation from the skin is increased by increasing air exchange, air flow and the evaporation of supplemental water applied to the skin.

Freestall barns that are correctly designed will provide maximum natural ventilation. However, additional cooling equipment is necessary to maintain milk production and reduce its decrease during summer. In addition to maintaining production, heat abatement measures must be cost effective and return a net profit to the dairy producer. A study was conducted during the summer of 2000 to evaluate two different cooling systems in 4-row freestall barns located in northeast Kansas.

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[1]Department of Biological and Agricultural Engineering.

Procedures

During the summer of 2000 a study was conducted to determine if fans were only needed over the feedline. One hundred mid-lactation Holstein cows were blocked by milk production and day in milk and assigned randomly to each of four pens of a 4-row freestall barn. Two replicates, north and south halves of the barn, contained 2 pens each. Cows in each treatment group averaged 173 days in milk and produced an average of 97.6 lb/cow/day at the start of the study. Pens contained 85-90 cows. In each pen, 25 were study animals. Fan treatments were either a single row of 36-inch fans mounted every 24 ft on the feedline (8, 36-inch diameter circulation fans with 0.5 horsepower motors) (feedline fans; F) or a single row of fans (8, 36-inch diameter circulation fans with 0.5 horsepower motors) mounted every 24 ft over the head-to-head freestalls plus another row of fans (8, 36-inch diameter circulation fans with 0.5 horsepower motors) mounted every 24 ft over the cow feedline (feedline and stall fans; F+S). Each fan was estimated to provide 10,000 cubic feet/min of airflow when operating.

Each pen was equipped with similar sprinkler systems consisting of 2.5 gallon/hr nozzles spaced every 78 inches on-center at a height of 8 ft above the headlocks. Sprinklers were on a 15-min cycle with 3-min on and 12-min off. Sprinklers were activated when the temperature was above 75°F. The designed application rate was 0.04 inches/ft^2 of surface area which consisted of 12 ft^2/headlock or a 24-inch feeding space. Total application rate was 50 gallons/cycle. Fans of all treatments were activated when the temperature was above 70°F both day and night. A description of fan and sprinkling systems is in Table 1.

Cows were milked 2× and milk production was measured every 2 wk throughout the 10-wk trial. All pens received the same diet. Amounts of feeds offered and refused were measured and recorded daily. Dry matter content of the diet and refusal of each was determined twice weekly. Cow respiration rates were measured on three separate days during heat stress. Fifteen cows were selected randomly from the 25 study cows in each pen and respiration rates were measured in the morning (0700-0800 hr), afternoon (1500-1600 hr) and at night (2200-2300 hr) on each of the 3 days.

Ambient and pen temperature and relative humidity were recorded every 15 min in two locations throughout the study with HOBO® Pro data loggers. Data from each day was averaged by 3-hr blocks of time beginning at midnight each day.

A switch back design with five 2-wk periods was utilized to evaluate fan placement. Cows and treatments were switched at the start of each period within each replicate. Milk and intake data were averaged by treatment within replicate and week prior to statistical analysis. Respiration rates were averaged by treatment within day, period and replicate prior to statistical analysis.

Results

Milk production (Figure 1) was greater ($P<0.01$) for cows exposed to F+S the treatment than for those exposed to the F treatment. Dry matter intake (Figure 2) tended ($P=0.11$) to follow a similar pattern as milk production with pen feed intakes (54.0 vs 52.7 lb/cow/d) greater when F+S was utilized rather than F. Milk production (Figure 3) was more consistent during the study for the F+S treatment compared to the F treatment. Milk production in periods 3 and 4 dropped 7 and 10 lb, respectively, for the F treatment, whereas milk in the F+S treatment did not drop greatly until period 4. Average ambient temperature (Figure 4) increased about 4.5°F during period 4 compared to period 3. If milk production by period is compared to period ambient temperature, it appears that the F+S maintained milk production over a longer period of the summer than did F. However, when ambient temperatures were the greatest, even F+S cattle experienced a significant drop in milk production, but not to the extent of cattle cooled with F. Based on the average pen temperature (Figure 5), no differences were observed between the treatments. It was possible that the F+S treatment allowed cattle to exchange greater amounts of heat while lying in the freestalls due to the increased airflow. Increased airflow likely would have increased evaporation rates of sweat and supplemental water from the skin surface.

Respiration rates (Figure 6) showed that the cattle exposed to F+S had reduced (*P*<0.06) respiration rates in the morning (71.7 vs 79.3 breaths/cow/min), at night (76.0 vs 80.1), and daily (79.4 vs 83.2) compared to those under F. Afternoon respiration rates were unaffected by treatment. Respiration data indicate that the cattle treated with F+S were more comfortable than those cooled with F.

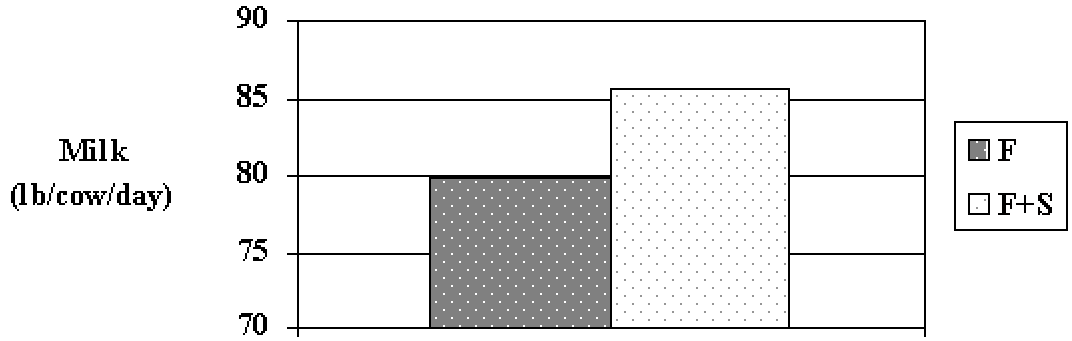
An economic analysis (Table 2) suggested that production losses due to heat stress were reduced from an estimated 20% with no heat abatement system (no fans or sprinklers) to 12% (F) and 5.6% (F+S). The cooling response of F was 7.3 lb of milk and that of F+S was 13.1 lb of milk relative to no heat stress abatement practice. Total cost to install cooling equipment was $3,536 (F) or $7,072 (F+S) per pen of 84 cows. Estimated increased milk income for and 85-day cooling season was $6,730 (F) or $12,114 (F+S) per pen. Estimated net income after accounting for ownership, operation, and additional feed expenses was either $3,656 (F) or $6,693 (F+S) for a pen of 84 cows. On a cow per day basis, net returns were either $0.51 (F) or $0.94 (F+S) for the 85-day cooling season. A 100-cow Kansas dairy could expect to receive an additional $4,335 (F) or $7,990 (F+S) by utilizing these heat abatement techniques. Additional net income would pay for the complete system in a single year.

This study clearly demonstrated that cows in a 4-row freestall barn produced more milk and had lower respiration rates by locating fans on both the feedline and over the freestalls. Based on lower respiration rates in the morning and at night, the duration of heat stress was reduced by the F+S treatment. Appropriate fan location in combination with feedline sprinklers reduced heat stress in lactating dairy cattle housed in a 4-row freestall building. In addition, heat abatement measures can be effective and profit generating.

Table 1. Description of Building and Cooling Treatments on Utilized to Determine the

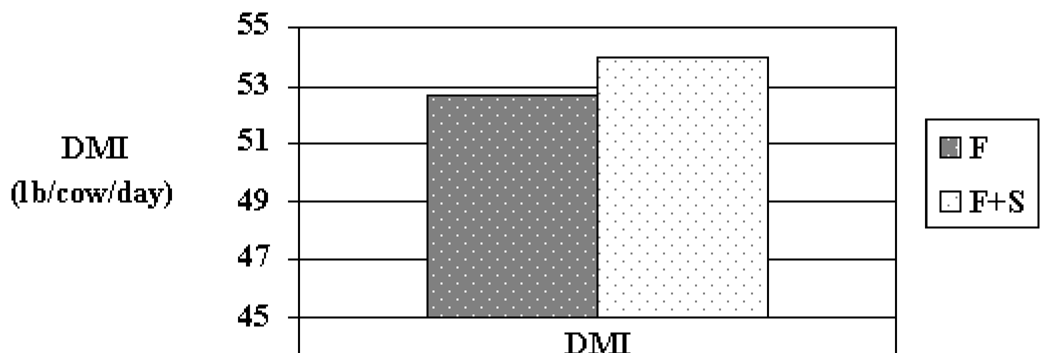
	Fan Treatment[1]	
Cooling System	F	F + S
Sprinklers		
Sprinklers location	feedline	feedline
Nozzle rating, gallons/hr	25	25
Nozzle type	180	180
Sprinkler cycle	on - 3 min	on - 3 min
	off - 12 min	off - 12 min
Sprinkler height, ft	8	8
Fans		
Rows over freestalls	0	1
Rows over feedline	1	1
Number of fans per row	8	8
Total number of fans	8	16
Fan spacing, ft	24	24
Fan diameter (hp)	36 in (1/2 hp)	36 in (1/2 hp)
Fan airflow/stall, cfm/stall	0	950
Fan airflow/headlock, cfm/head	800	800

[1]Building description: Building type: 4 row; Orientation: East-West (2% slope to west); Dimensions: width-100 ft, length-420 ft, sidewall height-14 ft, roof slope-4/12; Configuration: 4 pens with 84 stalls per pen and 100 headlocks per pen. [2]F=one row of fans over feedline and F + S=one row of fans over the feedline and one row of fans over the head-to-head freestalls.



F	79.8
F+S	85.6

Figure 1. Average Milk Production of Lactating Holstein Cows Exposed to Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S).



F	52.7
F+S	54.0

Figure 2. Average Pen Dry Matter Intakes of Lactating Holstein Cows Exposed to Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S).

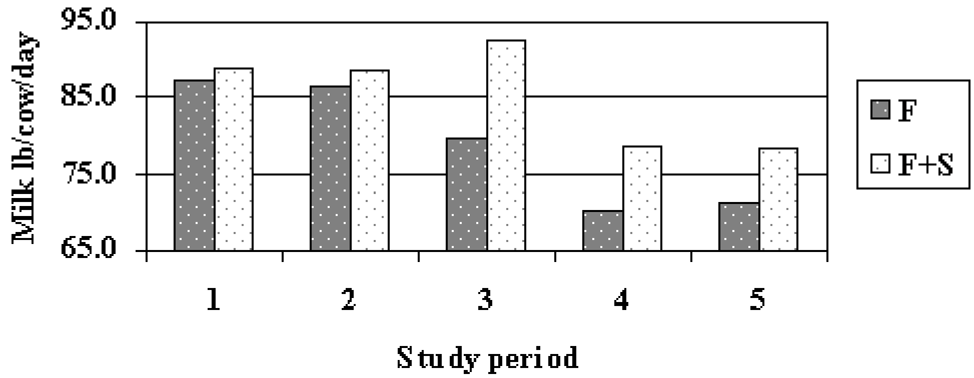


Figure 3. Average Milk Production by Period of Study of Lactating Holstein Cows Exposed to Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S).

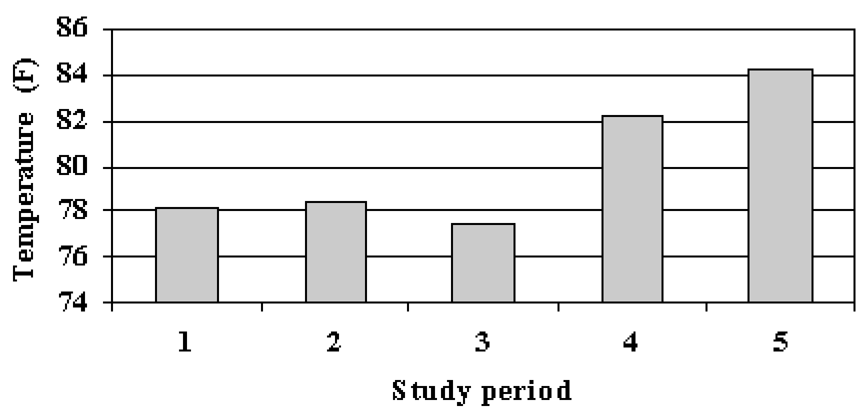


Figure 4. Average Daily Ambient Temperature During Study.

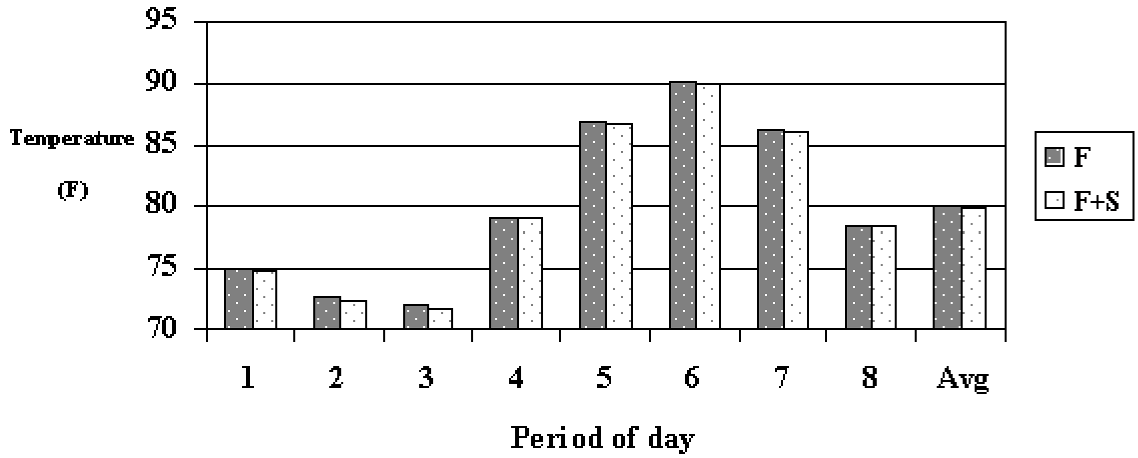
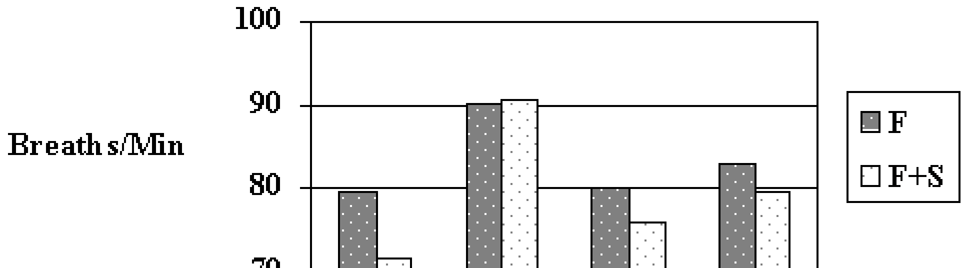


Figure 5. Average Temperature of Pens Cooled with Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S) at Different 3-Hour Periods of the Day.



	Morn	After	Nite	Avg
F	79.3	90.1	80.1	83.2
F+S	71.7	90.6	76	79.4

Figure 6. Average Respiration Rates of Cows Exposed to Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S).

Table 2. Economic Analysis of Using Either Fans over the Feedline (F) or Fans over Both the Feedline and Freestalls (F+S)[1]

	Treatment[2]	
Item	F	F + S
Beginning milk production, lb/cow/d	97.6	97.6
Milk production w/o cooling, lb/cow/d	72.5	72.5
Average milk production w/ cooling, lb/cow/d	79.8	85.6
Production loss due to heat stress w/ cooling, %	12.0	5.6
Cooling response, lb/cow/d	7.3	13.1
	- - - - - - - - - - - -$- - - - - - - - - - -	
Total extra income due to cooling, pen	6,730	12,114
Fixed and installation cost of fans, pen	3,536	7,072
Total fixed cost of cooling systems, pen	4,036	7,572
Annual fixed fan cost, pen/yr	505	1,010
Annual fixed sprinkler cost, pen/yr	100	100
Total sprinkler water usage, gal/pen/yr	189,567	186,428
Cost of water for sprinklers, pen/yr	303	298
Total cost of electricity for fans, pen/yr	445	890
Total Variable cooling cost, pen/yr	748	1189
Additional feed cost per cow, cow/d	0.20	0.35
Additional feed cost per pen, pen/yr	1,398	2,516
Gross income due to cooling system, pen/yr	6,730	12,114
Operating cost due to cooling system, pen/yr	3,074	5,420
Extra income due to cooling system, pen/yr	3,656	6,693

[1]Assumptions of Economic Model

- 84 cows per pen
- 85 days of heat stress
- $13/cwt milk price
- $1.60/1,000 gal of water
- 20% reduction in milk production without cooling system

[2]F=one row of fans over feedline and F + S=one row of fans over the feedline and one row of fans over the head-to-head freestalls.

INFLUENCE OF FREESTALL BUILDING ORIENTATION ON COMFORT OF LACTATING DAIRY CATTLE DURING SUMMER HEAT STRESS

J. F. Smith, M. J. Brouk, and J. P. Harner [1]

Summary

A trial was conducted during the summer of 2000 to evaluate the effect of freestall building orientation—east-west vs. north-south—on respiration rates of lactating dairy cows, temperature-humidity index (THI) in the barns, barn temperature, and barn humidity. Differences between ambient and barn temperature and THI were higher in east-west vs. north-south orientated barns. Respiration rates were higher in north-south than in east-west orientated structures. The magnitude of differences between barn and ambient temperatures and THI did not fully explain differences in respiration rates between north-south and east-west orientated barns. Other factors such as solar radiation, airflow, and animal stress may have contributed to the differences in respiration rates.

(Keywords: Heat Stress, Freestalls, Cow Comfort.)

Introduction

Dairy cows housed in north-south vs. east-west orientated 4-row freestall barns are potentially exposed to more direct sunlight than those in barns orientated east-west. Figure 1 demonstrates how cows are exposed to direct sunlight throughout the day in a 4-row frestall barn orientated north-south. Concerns have been raised about the level of heat stress in freestall buildings orientated north-south vs. east-west.

Procedures

A trial was conducted during the summer of 2000 near Tulare, CA, to evaluate the effect of freestall buildings orientated east-west vs. north-south on respiration rates of lactating dairy cows, THI in the barns, barn temperature, and barn humidity. Six freestall barns (3, north-south and 3, east-west) on 6 farms were utilized to collect temperature and humidity readings every 15 min at four locations per barn. Ambient temperature and humidity were collected at two locations in close proximity to each freestall barn. All temperature and humidity data were collected using HOBO data loggers programmed to collect data every 15 min, 24 hr per day. Temperature and humidity data were collected continuously from April through August of 2000. Respiration rates were collected in the morning between 6 and 8 and between 2 and 4 in the afternoon on three different days. During each observation period, respiration rates were collected from 50 cows in each barn.

Results and Discussion

Average ambient temperature, humidity, and temperature humidity index (THI) of north-south vs. east-west freestall barns are presented in Table 1.

Average differences between ambient and barn temperature and THI were higher (P<0.01) in east-west vs. north-south structures (Table 2). Average temperature was 0.45°F higher and THI difference was 0.7 higher in east-west buildings. Relative

[1]Department of Biological and Agricultural Engineering.

humidity difference was 0.62% lower (P<0.05) in east-west vs. north-south barns.

Respiration rates were higher (P<0.05) in the morning and afternoon in north-south vs. east-west orientation (Table 3).

Conclusions

Temperature and THI were higher in east-west vs. north-south orientated barns compared to ambient conditions. Respiration rates were higher in north-south vs. east-west orientated structures. Differences in barn temperatures and THI did not explain differences in respiration rates between north-south and east-west orientated barns. Other factors such as solar radiation, airflow, and animal stress may have contributed to the differences in respiration rates.

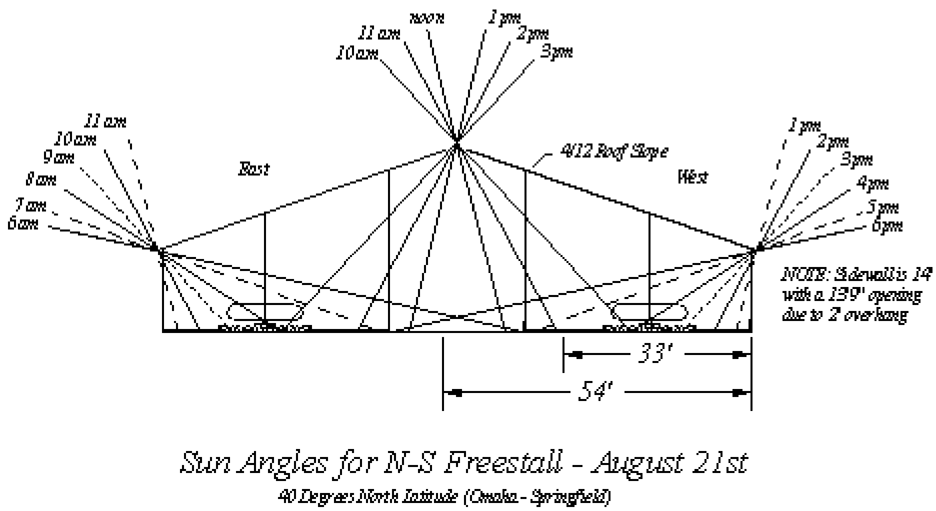


Figure 1. Sun Angles for a 4-Row Freestall Building Orientated North-South.

Table 1. Average Temperature, Relative Humidity and THI of East/West and North/South Barns for Three Days of Respiration Measurements

Item	E/W	N/S	Location effect (*P* value)
Ambient temperature, °F	73.6	73.4	0.57
Ambient relative humidity, %	54.4	53.3	0.06
Ambient THI	68.2	68.0	0.15

Table 2. Average Difference[1] between Barn and Ambient Temperature, Relative Humidity, and THI

Item	E/W	N/S	Barn effect (*P* value)
Temperature °F	+0.43	−0.02	0.01
Relative humidity, %	−0.28	+0.44	0.05
THI	+0.7	+0.4	0.01

[1]Differences in temperature, relative humidity, and THI between inside and outside the barns.

Table 3. Average Morning and Afternoon Respiration Rates of Cows Housed in N/S verses E/W 4-Row Freestall Barns Located in California

Barn type	Morning	Afternoon	Average
	------------------------ Breaths per min	----------------------------	
East/West	52.2[a]	68.8[a]	60.5[a]
North/South	56.4[b]	77.4[b]	66.9[b]

[a,b]Means within the same column differ ($P<0.05$).

EFFECT OF HEADLOCKS ON MILK PRODUCTION AND FEED INTAKE OF DAIRY CATTLE

M. J. Brouk, J. F. Smith, J. P. Harner, III [1], and S. E. DeFrain

Summary

Cows previously trained with headlocks did not increase milk production or feed intake when headlocks were removed. Two-year-old and older cows did not differ in response to headlocks and neckrails. Prudent use of headlocks increases labor efficiency of a commercial dairy. Managing a dairy without headlocks is a challenge because cows must be sorted and worked off the milking parlor flow. In the case of large milking parlors, it may be necessary to process 50-200 cows per hour. Depending upon the treatment facilities, this number of cows may create a bottleneck in the dairy. For many routine procedures, headlocks offer the simplest and most cost-effective alternative. It is important to note that headlocks can be mismanaged. This is especially true during summer months. Locking up cows for extended periods without access to water or shade may have adverse effects during summer heat stress. It is important to minimize lock-up time. Consideration should also be given to training heifers to headlocks prior to calving. It is very likely that untrained heifers may be reluctant to be placed in headlocks. If this occurs, intake could be limited during their first exposure to headlocks. If heifers are not trained to headlocks prior to calving, one should determine if they should be locked-up each day during the first week of lactation. Headlocks can be successfully used on a dairy. The critical question is how will they be managed. Successful managers of headlocks minimize restraint time, push-up or feed pens often (6-8 times per day), and avoid use of headlocks during late morning and afternoon hours during the summer months.

(Key Words: Cow Comfort, Restraint, Stress.)

Introduction

Headlocks or self-locking stanchions have been utilized for animal restraint necessary for many routine dairy husbandry procedures for several decades. Headlocks allow a single person to restrain a group of cows, increasing the labor efficiency of routine animal care including breeding, pregnancy exam, vaccination, injections, and other procedures. Within the last decade, some concerns have been raised about the effects of headlocks on milk production and feed intake. Several studies showed that extended lockup time (4 hr) did not affect feed intake or milk production. One study showed a decrease in milk with extended lock-up time, but similar feed intake. Another study found a decrease in intake without a difference in milk production. Therefore, a study was conducted during the summer of 2000 to determine the effect of headlocks and neckrails on milk production and dry matter intake of lactating dairy cows on a commercial dairy.

Procedures

Mid-lactation Holstein cows were housed in head-to-head 2-row freestall buildings equipped with 100 freestalls and identical cooling fans located over the freestalls and low-pressure feedline sprinkling systems.

[1]Department of Biological and Agricultural Engineering.

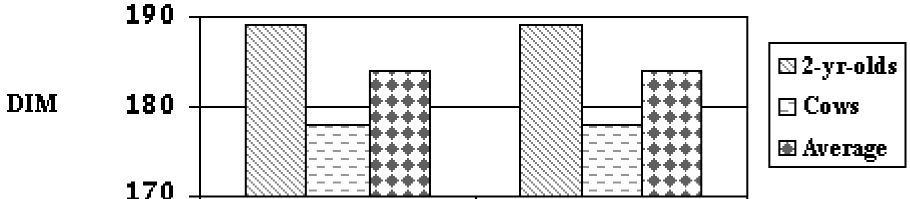
The two barns were located on a northeast Kansas dairy and stocked with 108 mid lactation Holstein cows (55 2-year-olds and 53 cows). Each barn contained 220 ft of bunk space with 110 headlocks and 100 freestalls. A total of 108 cows were allotted to each barn, resulting in an overstocking of stalls by 108% and headlocks stocked at 98% of capacity. Headlocks were manufactured by a local company and utilized 2 linear ft per lock. Headlocks when locked provided a neck area of 8 × 32 in. When open, headlocks provided a top opening of 13.5 in.

Cows were blocked by lactation number, days in milk, and production, then randomly assigned to each of two treatments. Initial milk production and days in milk for each treatment are illustrated in Figures 1 and 2. Treatments were headlocks or neckrails. A switchback design was used and the treatments (headlocks and neckrails) were switched between the buildings. The study was done in two 4-week periods. Cows were milked three times and amounts recorded electronically for each milking, using an automatic identification system. Both barns received an identical TMR and the amounts fed and refused were recorded daily. Dry matter of the feed and refusals were determined twice weekly. Milk production data were averaged by lactation number and week within period for each treatment. Feed intake data were averaged by week within each period for each treatment. Averaged data were then analyzed for the effects of treatment, period, parity, and week.

Results

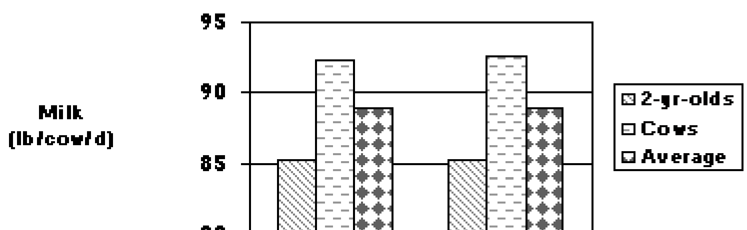
Average dry matter intakes (Figure 3) were similar for both treatments averaging 51.8 and 50.4 lb/c/d for neckrail and headlock treatments, respectively. Average milk production (Figure 4) was similar for both neckrail and headlock treatments. First-lactation and older cows produced similar amounts of milk when exposed to either treatment (Figure 5). Results from this study indicated that on a commercial dairy, headlocks did not adversely affect milk production or dry matter intake of cattle trained to headlocks. Removal of the headlocks did not increase milk production or feed intake.

In summary, it does not appear that headlocks adversely affect milk production or feed intake on commercial dairy farms. It should be emphasized that the cows involved in this study had been previously trained to headlocks.



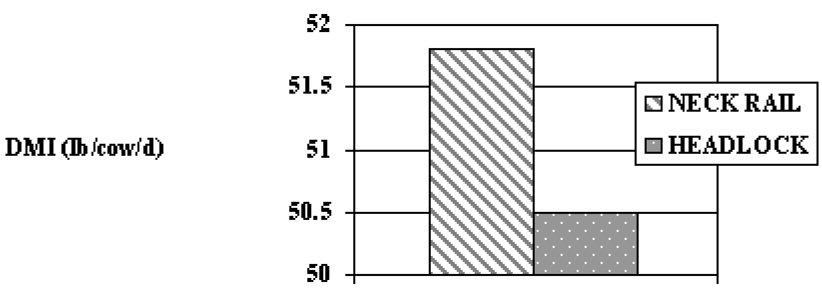
	Headlock	Neckrail
2-yr-olds	189	189
Cows	178	178
Average	184	184

Figure 1. Initial Days-in-Milk of Treatment Groups of Lactating Dairy Cattle Exposed to Either Headlock or Neckrail Feed Barriers.



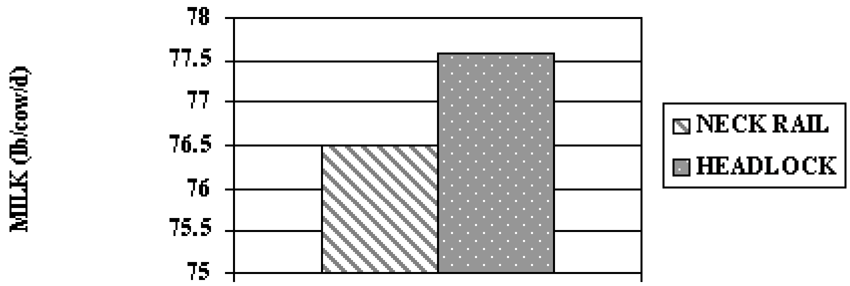
	Headlock	Neckrail
2-yr-olds	85.3	85.3
Cows	92.4	92.6
Average	88.9	88.9

Figure 2. Initial Milk Production of Treatment Groups of Lactating Dairy Cattle Exposed to Either Headlock or Neckrail Feed Barriers.



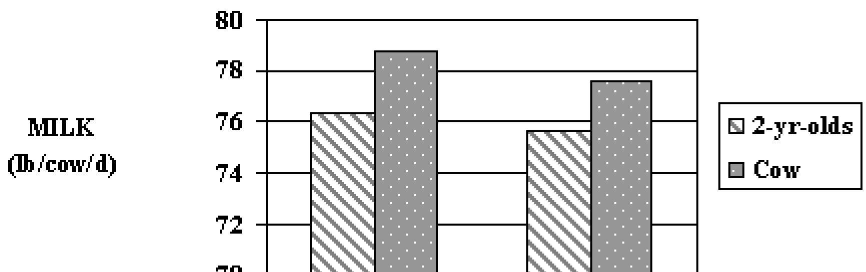
NECK RAIL	51.8
HEADLOCK	50.5

Figure 3. Average Dry Matter Intake of Treatment Groups of Lactating Dairy Cattle Exposed to Either Headlock or Neckrail Feed Barriers.



NECK RAIL	76.5
HEADLOCK	77.6

Figure 4. Average Milk Production of Treatment Groups of Lactating Dairy Cattle Exposed to Either Headlock or Neckrail Feed Barriers.



	Headlock	Neckrail
2-yr-olds	76.3	75.6
Cow	78.7	77.6

Figure 5. Average Milk Production of Heifers and Cows Exposed to Either Headlock or Neckrail Feed Barriers.

IMPACT OF DAIRY MANURE ADDITION ON SOIL NUTRIENTS IN NORTHEAST AND SOUTH CENTRAL KANSAS

T. Strahm [1], J. P. Harner [1], J. P. Murphy [1], D. V. Key [2], G. McCormack [3], M. J. Brouk, and J. F. Smith

Summary

Sixty four percent of the fields (14 of 22) in northeast and south central Kansas would be able to apply dairy manure on a nitrogen basis if the current swine manure application regulations were adopted. Due to high phosphorus levels in some fields, two of the 11 fields in northeast Kansas could not have any manure applied to them. Two other fields in northeast and four fields in south central Kansas would have to limit manure application rates to annual phosphorus required by the crops. Our results indicate minimal accumulation of nitrogen and potassium in the soil profile.

(Key Words: Nutrients, Soil, Manure.)

Introduction

Nutrients are recycled to the land during manure application. Best Management Practice (BMP's) require laboratory analysis of the manure nutrients and soil sampling. Many producers utilize results from soil sampling and analysis to determine application rates for commercial fertilizers. Manure may be applied to the land after application of fertilizers without consideration of the potential to accumulate nutrients in the soil profile. Kansas regulates the quantities and amounts of swine manure that may be applied to fields. The application rates are based on yearly soil tests. The objective of this study was to determine the nutrient content in soil profiles that receive dairy manure and to determine the impact of the swine regulations if they were applied to the dairy industry.

Study Procedures

Eleven fields from seven dairies in northeast Kansas and 11 fields from five dairies in south central Kansas were selected for this study. The fields receiving manure in northeast Kansas were predominately clay soils. Those in south central region were sandy soils. Soil samples were collected randomly throughout the fields. At least 10 soil samples were collected from each field. Samples from each field were thoroughly mixed and composite samples were sent to the Kansas State University (KSU) Soils Lab. Soil cores were collected at 0 to 6 inches and 6 to 24 inches. Samples were analyzed for phosphorus, potassium, ammonium and nitrate. The available nitrogen per acre was estimated using an agronomic equation.

Results

Figure 1 shows the soil phosphorus (P) concentrations at 0 to 6 inch and 6 to 24 inch depths from fields located in northeast Kansas. The P concentrations ranged from 15 to 345 ppm in the top 6 inches. Fields 2W and 4E exceeded 150 ppm in the top 6 inches. Using the swine regulations, no manure could be applied to these fields because the P level exceeded 100 ppm. Fields 4W and 9W could have manure applied based on the crop P use rate rather than nitrogen. Manure

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[2]Nemaha County Extension Agent.
[3]Reno County Extension Agent.

applications to seven of the 11 (64%) fields could still be based on crop nitrogen use. Soil P levels from 6 to 24 inches ranged from 0 to 31 ppm. Again, fields 2W and 4E had the highest P concentrations at 31 and 20 ppm, respectively.

Potassium (K) concentrations ranged from 197 to 475 ppm, except field 2W (1,256), for the top 6 inches (Figure 2). At soil depths of 6 to 24 inches, K concentrations ranged from 142 to 347 ppm, except 4E (962). With the exception of these two fields, decreases in K from 0 to 6 inches and soil depths of 6 to 24 inches appeared fairly consistent.

Figures 3 and 4 show the ammonium and nitrate concentrations in the soil profile. Ammonium concentrations from 0 to 6 inches varied from 3.5-8.5 ppm and reduced to 1.4 to 3.6 ppm at soil depths of 6 to 24 inches (Figure 3). Nitrate concentrations in five fields ranged from 5-10.2 ppm in the top 6 inches. The remaining fields had nitrate concentrations ranging from 22.5 to 76 ppm. The 6 to 24 inch samples showed a similar pattern. The five fields with lower levels in the upper profile have nitrate concentrations of from 0.6 to 5.9 ppm in the deeper profile. The other six samples varied from 11.5 to 24.1 ppm.

Figure 5 shows an estimate of the nitrate available on a per field basis in northeast Kansas. Nitrate concentrations in the soil profile from 0 to 24 inches exceeded 150 lb/acre on five of the 11 fields.

Figure 6 shows the soil phosphorus (P) concentrations at 0 to 6 inches and 6 to 24 inches from fields located in south central Kansas. The P concentrations ranged from 15 to 76 ppm in the top 6 inches. No fields had P concentrations high enough to limit application of manure using the swine regulations. Fields 4E, 5N, 7E and 7S could have manure applied based on the crop P usage rate rather than nitrogen. Manure applications to seven of the 11 (64%) fields could still be based on crop nitrogen usage. Soil P concentrations from 6 to 24 inches were less than 20 ppm.

Potassium (K) concentrations ranged from 105 to 350 ppm for the top 6 inches (Figure 7). At soil depths of 6 to 24 inches, K concentrations ranged from 100 to 190 ppm. With the exception of three fields, decreases in K from 0 to 6 inches to soil depths of 6 to 24 inches appeared fairly consistent.

Figures 8 and 9 show the ammonium and nitrate concentrations, respectively, in the soil profile. The ammonium levels from 0 to 6 inches varied from 2.8-14.2 ppm and reduced to 1.5 to 8.6 ppm at soil depths of 6 to 24 inches (Figure 8). Nitrate concentrations in the fields ranged from 7.5 to 25 ppm in the top 6 inches. The results indicate leaching of nitrates in some fields such as 7E, 7S, 7N and 4E.

Figure 10 shows an estimate of the nitrate available on a per field basis in south central Kansas. Nitrate concentrations in the 24 inch soil profile exceed 100 lb/acre on two of the 11 fields.

Conclusions

In south central Kansas, no fields receiving manure showed high concentrations of P and nitrate (NO3-N) in the soil profile (0 to 24 inches). The K concentrations varied depending on the depth in these fields. None of the farms appear to have fields with excess nutrients. In northeast Kansas, two fields showed high concentrations of P and nitrate (NO3-N) in the soil profile (0 to 24 inches). The K concentrations varied depending on the depth in these fields. Only one of the farms seems to have soils with excess nutrients. Data from this preliminary study suggest that 64 % of the fields where dairy manure is applied would be in compliance with the current swine regulations. Manure application rates on six fields would need to be adjusted to meet the crop phosphorus requirements.

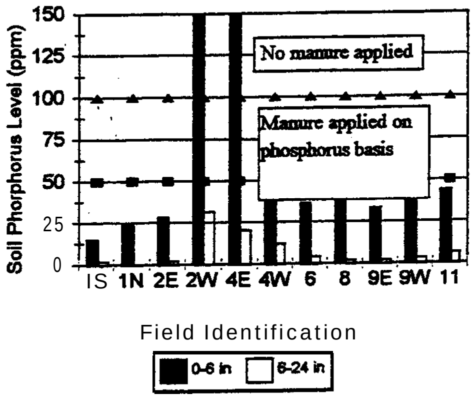

Figure 1. Soil Phosphorus Concentrations from Fields in Northeast Kansas Receiving Dairy Manure.

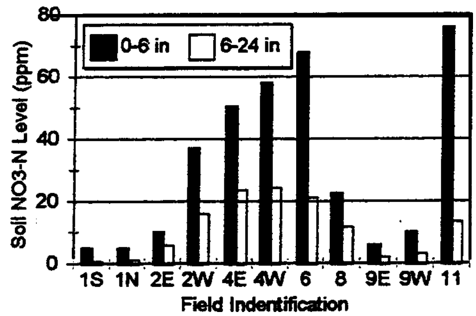

Figure 4. Soil Nitrate Concentrations from Fields in Northeast Kansas Receiving Dairy Manure.

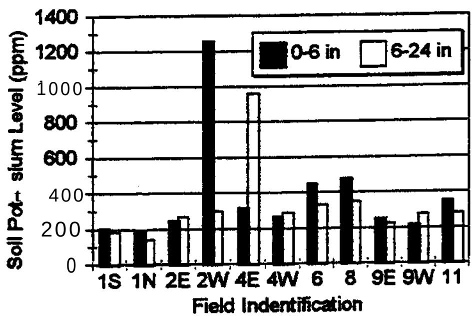

Figure 2. Soil Potassium Concentrations from Fields in Northeast Kansas Receiving Dairy Manure.

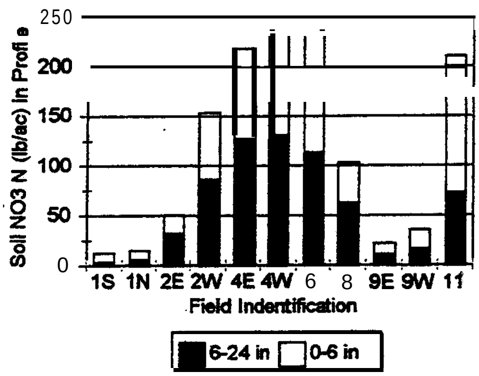

Figure 5. Soil Nitrate (lb/acre) Available for Crop Utilization from Fields Receiving Dairy Manure in Northeast Kansas.

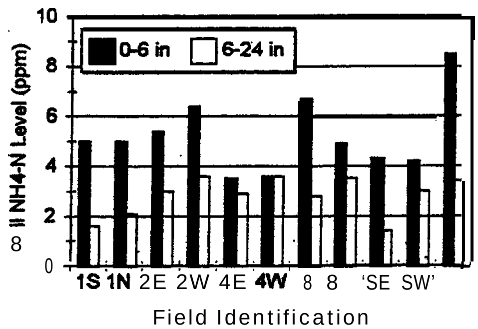

Figure 3. Soil Ammonium Concentrations from Fields in Northeast Kansas Receiving Dairy Manure.

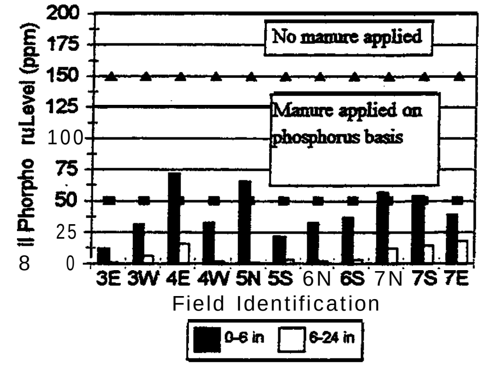

Figure 6. Soil Phosphorus Concentrations from Fields in South Central Kansas Receiving Dairy Manure.

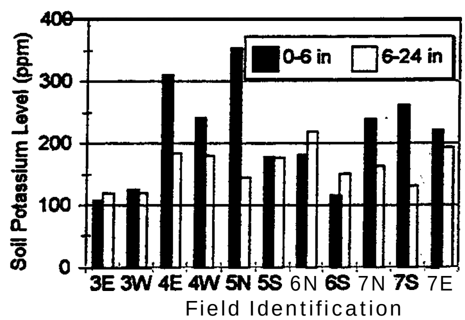

Figure 7. Soil Potassium Concentrations from Fields in South Central Kansas Receiving Dairy Manure.

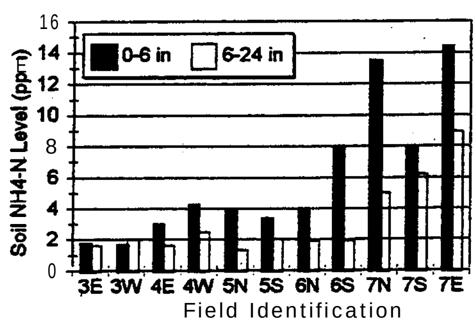

Figure 8. Soil Ammonium Concentrations from Fields in South Central Kansas Receiving Dairy Manure.

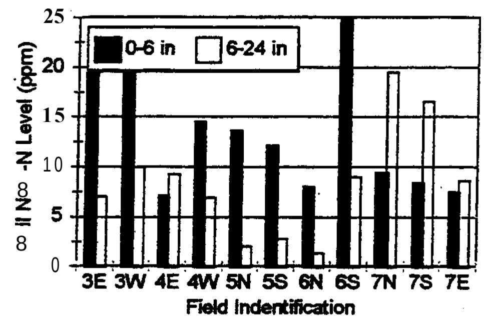

Figure 9. Soil Nitrate Concentrations from Fields in South Central Kansas Receiving Dairy Manure.

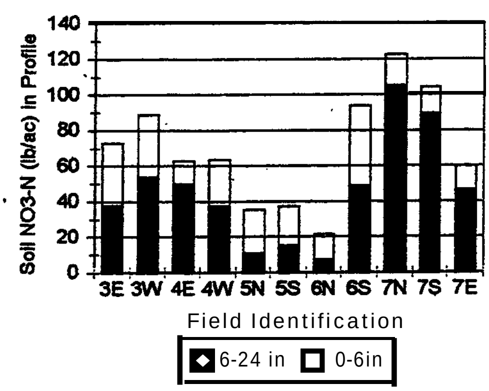

Figure 10. Soil Nitrate (lb/acre) Available from Crop Utilization from Fields Receiving Dairy Manure in South Central Kansas.

EXTRALABEL MASTITIS THERAPY: WHAT DOES IT MEAN?

J. R. Roberson [1]

Summary

Extra-label drug use (ELDU) is needed to provide optimal therapy for ill dairy cattle. Proper ELDU requires cooperation and compliance between the veterinarian and producer to ensure that proper drug withdrawal times are observed.

(Key Words: Regulations, Mastitis, Therapy.)

A Severe Case of Clinical Mastitis

This case is presented as a "real-life" situation in which the suitability and legality of therapy will follow. On August 21, a 6-year-old 1400 lb Holstein cow 109 days in milk is presented with a temperature of 101.8°F, a heart rate of 92, a respiratory rate of 32, adequate rumen contractions, and a noticeably swollen but not hard quarter. She is 7-9% dehydrated, depressed, not eating, and not ketotic. Upon exam of her milk from the affected quarter, there are many clots in the watery secretion. There are no other abnormalities present. The first step in managing this cow would be to assess her severity level, which could easily be severe based on her elevated heart rate and her dehydration. The next step would be to approach the management of this case with FANO (Fluids, Antibiotics, Non-steroidal anti-inflammatory, and Other). The cow is 7-9% dehydrated but still standing and the rumen contractions seem normal. Administer 2 liters of 7% hypertonic saline followed by at least 12 gallons of oral fluids spiked with regular salt and diet salt. Because around 30% of cows with severe mastitis develop bacteria in the bloodstream, use a good broad-spectrum antibiotic (Naxcel®). Then collect a milk sample for culture and treat intramammary (IMM) based on the results of the culture the following day. Administer 15 ml of an anti-inflammatory drug (Banamine®) intramuscularly (i.m.) and oral and subcutaneous calcium.

The following day *E. coli* grows as a lawn (colonies too numerous to count) on blood agar. The cow is re-evaluated the following morning and her temperature is now 104, pulse 94, respiratory rate 38, her rumen motility is still okay and she does not appear dehydrated. Continue the Naxcel at the labeled dose and repeat the Banamine. Treat her intramammary infusion with 6 ml of ceftiofur HCl (Excenel®) twice daily for 3 days. Fluids were repeated on days 3 and 4. Banamine was repeated on day 3. Intramuscular Naxcel was continued through day 5.

Was My Clinical Mastitis Therapy Legal?

Neither Naxcel nor Excenel have a label claim for treatment of clinical mastitis. Is there any antibiotic approved for clinical mastitis or bacteria in the blood for treatment in lactating dairy cows? No, but how would you find this information?

- Go to the website: http://www.fda.gov/cvm/
- Click on "Greenbook"
- Click on "FDA Approved Animal Drug Products On-Line Database System"

[1]Department of Clinical Sciences.

- Click on "Approved Animal Drug Products (Advanced)"
- Type in the generic name of an antimicrobial and refine the search by adding a descriptor (e.g., amoxicillin and cattle). You could also enter mastitis.
- For this example:

Field	Search Term	Records
All Fields	amoxicillin and cattle	4

- Now click on display records.

The only systemic use antibiotics with label indications for lactating dairy cattle are amoxicillin, ampicillin, ceftiofur, erythromycin, oxytetracycline, penicillin, and sulfadimethoxine. None have label indications for clinical mastitis or bacteremia. Therefore, systemic antimicrobial therapy for treatment of clinical mastitis or bacteremia is extralabel. Was it an acceptable ELDU?

Extralabel Drug Use (ELDU)

- ELDU is not permitted if a drug exists that is labeled for the food animal species and contains the needed ingredient, in the proper dosage form, labeled for the indication, and is clinically effective. Okay here.
- ELDU is permitted only by or under the supervision of a veterinarian. Okay here.
- ELDU is allowed only for FDA approved animal and human drugs. Okay here.
- ELDU is permitted for therapeutic purposes only when an animal's health is suffering or threatened. Okay here.
- ELDU is not permitted if it results in a violative food residue, or any residue that may present a risk to public health. Okay here.
- ELDU requires scientifically based drug withdrawal times to ensure food safety. Okay here.

An American Veterinary Medical Association (AVMA) ELDU algorithm has been developed to help with these decisions:

http://www.avma.org/scienact/amduca/amduca1.asp

One has a diagnosis of severe clinical mastitis made in the presence of a valid veterinary/client/patient relationship. When contemplating extra-label drug use for systemic antimicrobial therapy, one must ask:

1. Are the animals to be treated lactating dairy cows (food animals)? Yes or No.
   Yes, this is a food animal.
2. Does a lactating dairy cow (food animal) labeled drug exist that fulfills all of the following? Yes or No.
   - contains the needed ingredient
   - in the proper dosage form
   - labeled for the indication
   - clinically effective

   No, a labeled drug does not exist.
3. Is there a lactating dairy cow (food animal) approved drug which could be used extra-label? Yes or No.
   Yes, an approved drug can be used extra-label.
   - Proceed with Extra-label use of food animal drug.
   - Establish extended withdrawal time.
   - Ensure food safety.
   - Maintain required records.
   - Label drug appropriately.

Extralabel antimicrobial therapy must be prescribed only in accordance with the Animal Medicinal Drug Use Clarification Act amendments to the Food, Drug, and Cosmetic Act and its regulations (21 CFR Part 530). No drug can be marketed unless its quality, safety, and efficacy have been demonstrated. Thus, the first choice should be based on the products approved for the species and the indication concerned. When no suitable product is approved for a specific condition or species, or the approved product is considered to be clinically ineffective, the choice of an alternative product should be based, when possible, on the results of valid scientific studies and a proven efficacy for the condition and species concerned (www.fda.gov/cvm/index/fdavet/2000/septvet.htm). Based on ELDU guidelines and the algorithm, antimicrobials not labeled for lactating dairy cattle but still legal for use in cattle would be okay to use. However, it would seem prudent to use products that are approved for lactating dairy cattle as the meat and milk withdrawal times have been scientifically validated.

When no approved drug is available or when higher-than-approved dosages of approved drugs are needed, veterinarians must use their professional judgment regarding the benefits and risks to sick animals associated with extra-label use of drugs. Extra-label use for analgesic purposes is common because few animal-specific drugs have been approved for the relief of pain and suffering. Was use of Banamine extralabel and if so was its use appropriate? The answers to this are yes and yes. Anti-inflammatory drugs are often used to treat cases of clinical mastitis and none have a label claim specific for mastitis. However, our purpose in administering these drugs is to decrease fever, swelling, inflammation, and combat endotoxin. Based on reasons and listed indications in Table 1, Banamine is an acceptable ELDU.

In the U.S., the only intramammary antibiotic labeled for clinical mastitis is pirlimycin, which that has proven efficacy against staphylococcus and streptococcus species. Indications for some of the other intramammary antibiotics imply clinical mastitis therapy but use words such as acute or chronic mastitis or administer at first signs of inflammation or any alteration in the milk. So was the use of intramammary ceftiofur HCL extralabel? Yes. But the use of intramammary ceftiofur HCl appears to be an appropriate ELDU because no approved and proven effective products for severe clinical coliform mastitis exist. But let's go a step further. Are there other requirements?

One of the provisions the AVMA persuaded the Center for Veterinary Medicine (CVM) of the U.S. Food and Drug Administration (FDA) to include in its regulations allows extralabel use when an approved drug is judged to be clinically ineffective for its intended use. But what about ampicillin (Hetacin K) that has the only approved intramammary label claim against *E. coli*. I could not find a single study published in a peer-reviewed journal that reported on the efficacy of intramammary ampicillin (as the sole treatment) for clinical mastitis. Ampicillin in combination with other antibiotics has been reported to be inferior to other intramammary preparations. However, when the ampicillin and cloxacillin preparation was compared only to itself with no controls, the results looked a lot better. When the same ampicillin/cloxacillin preparation was compared to either parenteral cefquinome therapy, with or without intramammary cefquinome (cures of 82.6 to 95.2%), against experimentally induced *E. coli*, results indicated that the ampicillin product (cures of 54.5%) was significantly inferior. This study supports the lack of efficacy of ampicillin and cloxacillin in the treatment of clinical coliform mastitis in dairy cows.

So what criteria must a practitioner use to justify extralabel use in a situation where the [approved] drug is ineffective? There is nothing in the regulations to guide veterinarians in making this assessment. FDA recognizes that it is the professional judgment of a veterinarian to make that determination. Veterinarians aren't required to state their criteria as to why they thought the drug was ineffective but economics should not be used as justification of ELDU. So is the extralabel intramammary use of ceftiofur effective for severe clinical *E. coli* mastitis? Yes, it is. Figure 1 indicates the daily colony forming units (cfu) for the case presented. The first two data points were prior to any intramammary ceftiofur. The third data point was after the first treatment and although it appears there was no effect on the cfu, cfu decreased. The cow was treated once on day 2, twice on day 3, twice on day 4 and once more on day 5. Only the case cow is presented here but this figure represents a typical cfu response of cows with coliform mastitis treated with intramammary ceftiofur.

Table 1. Anti-Inflammatory Drugs*

Drug	Approved Lactating	Indication	Milk Withdraw	Meat Withdraw
Aspirin	No official FDA approval	Fever reduction	1 d suggested	1 d suggested
Dexamethasone	Yes	Ketosis, inflammation	0	0
Predef 2X	Yes	Ketosis, inflammation	0	7 d
Flunixin meglumine	No	Pyrexia, endotoxemia, inflammation	4 d	4 d
Phenylbutazone	No	Inflammation of the musculoskeleton	5 d	45? d
Dipyrone	No	Prohibited		
Ketoprofen	No	Inflammation and pain of the musculoskeleton	1 d	7 d

*A selected reference for extralabel use of nonsteroidal anti-inflammatory drugs can be found in JAVMA 1997 Vol. 211, No. 7, pgs 860-861.

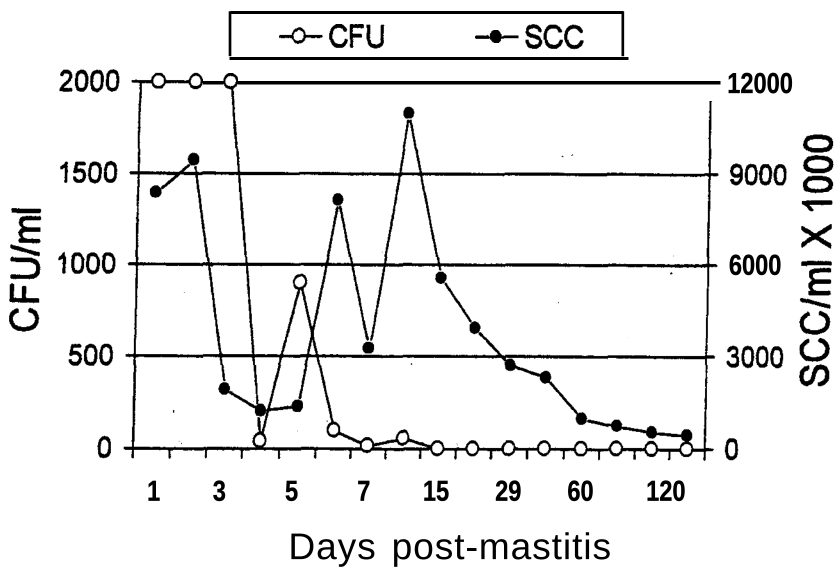

Figure 1. Colony-Forming Units and Somatic Cell Count by Days Post-Mastitis for a Case of Severe Clinical *E. coli* Mastitis.

IMPACT OF MILK PRODUCTION AND IMPORTANT MANAGEMENT FACTORS ON THE PROCESS OF DRY-OFF IN LACTATING DAIRY COWS

R. T. Dingwell[1]*, K. E. Leslie*[1]*, J. M. Sargeant*[2]*, Y. H. Schukken*[3]*, L. L. Timms*[4]

Summary

A study of 250 cows located in Canada and the United States revealed the rate of new mammary infections was 9.9% during the dry period. Average milk production on the day prior to dry-off was 13.2 ± 7.2 kg. The odds of a cow developing a new infection was three times greater if the cow was producing more than 5 kg of milk. After 6 weeks of the dry period, 25% of the teats still remained open. This research will serve as the foundation to investigate and implement management strategies prior to dry-off that might improve the overall udder health of dairy cows.

(Key Words: Dry-Off, Mastitis, Milk Production.)

Introduction

The dry period represents a crucial phase of the lactation cycle in order to achieve optimal productivity in the next lactation. Average duration of herd dry periods is correlated significantly with herd average milk production. As days dry deviate from 60 days, average milk production is negatively affected. Therefore, dairy herd managers justifiably aim to dry cows off to achieve dry periods of adequate duration. However, as the genetic potential for milk production of cows continues to increase, it becomes a greater challenge to move cows from lactation to the dry period. It is indeed surprising that very little is known about the impact various approaches associated with this management event have on udder health.

Much is known about the relative importance of the dry period itself with respect to udder health programs. The epidemiology of new infections during this time has been well documented as has the importance of those infections that persist into the next lactation. The goal of the dry period, to have as few quarters infected at the next calving as possible, can adequately be achieved by administering dry cow antibiotic therapy at the end of lactation. Recent research towards improving the success of the dry period has focused on methods to enhance the efficacy of antibiotic treatment, protecting teat ends from bacterial contamination, manipulation of udder involution, and vaccination with gram negative core antigens.

Other than the use of blanket antibiotic dry cow therapy, recommendations on managing dairy cows during the period from 2 weeks before until 2 weeks after dry-off are not well established. This is despite the fact that the risk of new intramammary infections (IMI) has been shown to be higher in the first 2 weeks of the dry period than during any other time of the production cycle. Risk of new IMI can be reduced if: 1) milk production was decreased before dry-off; 2) mammary involution proceeds rapidly during the dry period; 3) teat canals are sealed with a keratin plug in a timely manner; and 4)

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minimal contamination of teat ends occurs. Management factors affecting the rate of udder involution and formation of the teat canal keratin plug are not well described in the literature. Causal pathways describing the interactions of these factors and their relative influence on new IMI, either alone or in combination, are not well understood. This observational study was designed to investigate the influence and importance that specific cow and teat variables have on the efficiency of the dry-off process.

Procedures

Over 300 cows from four different research herds were enrolled in this study. Enrollment occurred 2 weeks before scheduled dry-off. At enrollment, teat ends of each cow were scored, an udder involution index was assigned, and quarter milk samples collected for bacterial culture. Teats were prepared aseptically according to the National Mastitis Council's recommended procedures and samples were submitted to the university mastitis laboratory associated with each research herd. Daily milk weights were recorded from enrollment until the day of dry-off. On the day of dry-off, teat-end scores, an udder involution index, and quarter milk samples were again obtained. Teat end scores were classified on a scale of 1-5, with 0.5 increments used to allow for differentiation of teats with cracks compared to normal teats or those with only hyperkeratosis. Herd specific procedures, including dry cow antibiotic therapy and application of a teat sealant, were performed and documented. Each cow was examined weekly for the first 6 weeks of the dry period. On the same day each week, teat end scores, udder involution and closure of the teat streak canal were assessed using previously published methods. Briefly, digital pressure was applied to each teat in a downward milking action. This action created pressure in the teat sinus, which resulted in one of two events occurring. If the applied pressure resulted in a drop of secretion forming at the teat end, the teat was classified as being open. In a closed teat, when the pressure was applied, the contents of the teat would slip upwards and no drop of secretion was produced because the teat end was sealed. Within the first week of calving, a California Mastitis Test was performed and milk samples were collected to determine the udder health status of the cow. Teat ends were scored once more and daily milk weights were recorded for the first 30 days of lactation.

Results and Discussion

Data from 290 cows dried off were analyzed for descriptive statistics and teat closure rate. Complete data including fresh milk cultures from 250 cows were analyzed to determine the rate of rate of new IMI and the effect that milk production had on this rate.

The population of cows dried off had a median parity of 2, average days in milk (DIM) of 319 ± 64, and an average teat end score of 2. A teat score of 2 indicates that the majority of teat ends had mild hyperkeratosis with no cracking present. Milk production data is shown for the 13 days prior to the day of dry-off (Figure 1). The average milk production on the day prior to dry-off was 13.2 ± 7.2 kg. Considerable variation existed in the decline of milk production over this time period among herds. Assessment of teat closure during the dry period revealed that 50% of teats remained open at the end of the first week. A teat was considered to be closed when it was assessed to be closed for two consecutive weeks. A steady decline in the number of open teats occurred each week; however, after 6 weeks of the dry period, 25% of teats were still open (Figure 2).

A total of 922 quarter milk-culture results collected from cows twice before and once after the dry period were available to determine the rate of cure and development of new IMI. On the day of dry-off, 20% of quarters cultured positive for a major mastitis pathogen. The majority of these infections were caused by environmental organisms: 1) other streptococci (5.2%); 2) *Escherichia coli* (3%); 3) *Streptococcus uberis* (2%); 4) and *Streptococcus dysgalactiae* (1.5%). *Staphylococcus aureus* was present in 6.8% of the milk samples. The cure rate of pathogens based on a single sample postcalving following regular dry cow antibiotic therapy is illustrated in Table 1.

The high cure rate for *S. aureus* was most likely due to only a single sample being collected, and may indeed have been less if multiple samples were used to define cure rate. The cure rate of other streptococci is comparable to that expected for this organism. The relatively low cure rate of *S. uberis* may be partially due to the few numbers of infections identified at drying off. Bacteriology was done at each site independently and some sites routinely identified the species of streptococci, whereas others did not.

Overall, the rate of new IMI in quarters during the dry period was 9.9% (99/992). Again, environmental pathogens contributed the majority of these infections. The species isolated most frequently were other streptococci (29%), followed by *E. coli* (13%), *Klebsiella* (11%) and other coliforms (7.1%). Only 10% of the new IMI were caused by *S. aureus*. The cure rates among the five different study sites are shown in Table 2. This observed cure rate of new IMI is what has been reported typically as the rate that occurs in cultured negative quarters during the dry period. One of the main objectives of this study was to examine the effect of milk production on this rate of new IMI.

The occurrence of new IMI in cows was calculated based on differing levels of milk production recorded on the day before drying- off. Earlier research has often placed 7-10 kg of milk as the critical level. No statistical association was detected in our data at either the 7- or 10-kg level. However, based on level of production alone, a cow was four times more likely ($P<0.05$) to develop a new IMI when her yield was greater than 5 kg on the day before dry-off. This result did not account for such potential confounding variables as parity, breed, days in milk (DIM), and herd. Hence, a logisitic regression model including these variables was performed. Again, cows producing >5 kg of milk prior to dry-off had increased ($P=0.06$) probability for a new IMI occurring (Table 3). The odds of a new infection were still three times greater in cows producing >5 kg of milk. It is often thought that cows producing lots of milk at dry-off are more likely to leak milk during the dry period and be at greater risk to develop new IMI. Our results indicate that a relationship exists between milk production and the development of new IMI, even at a level as small as 5 kg.

Other variables are undoubtedly involved. For instance, is teat closure of all four teats during the dry period an important variable? Producing >5 kg of milk had a sparing effect on a cow having all teats closed. In other words, the odds of a cow having all teats closed by 6 weeks into the dry period was less ($P<0.01$) at that level of milk production. However, no association was detected with teat closure at the cow level for development of new IMI when controlling for DIM, parity, and herd. The effect of the timing of teat closure during the dry period, as well as the impact of teat-end lesions, will be further investigated at the individual quarter level.

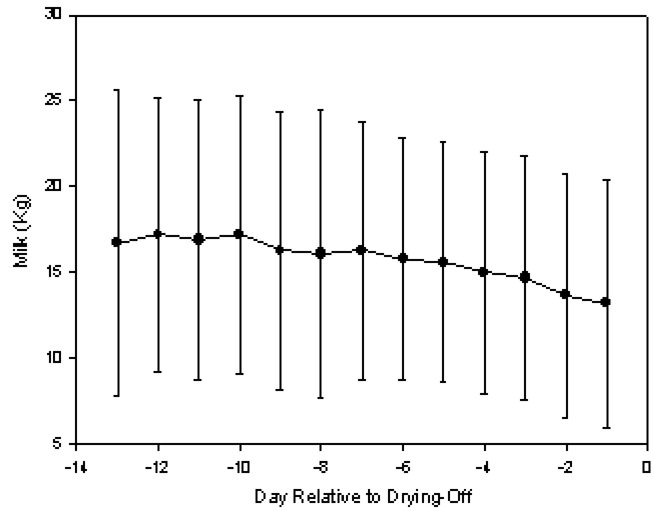

Figure 1. Daily Milk Production Relative to the Day of Dry-off.

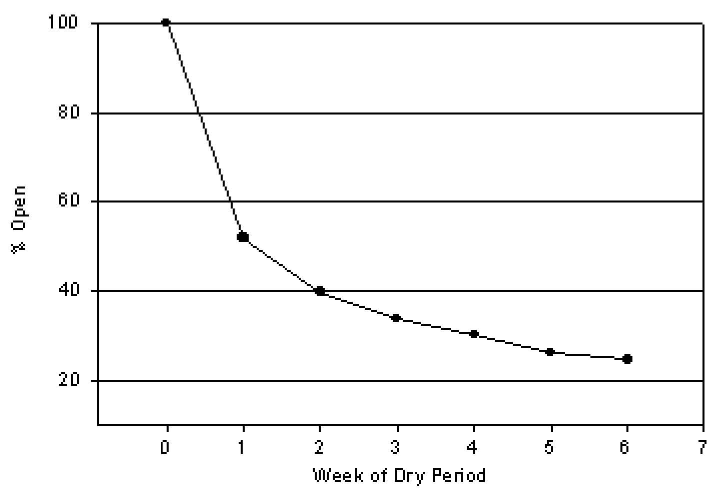

Figure 2. Percentage of Teats Closed During Each Week of the Dry Period.

Table 1. Prevalence of Major Mastitis Pathogens Cultured on the Day of Dry-Off and Cure Rate Following Dry Antibiotic Therapy

Organism	No. of quarters (% infected)	% cure rate
Other Streptococci	17 (5.0)	92.8
Streptococcus uberis	6 (2.0)	30.0
Streptococcus dysgalactiae	5 (1.5)	100.0
Escherichia coli	10 (3.0)	100.0
Klebsiella	2 (0.6)	50.0
Other coliforms	1 (0.3)	100
Staphylococcus aureus	22 (6.8)	82.0

Table 2. Rate of New Intramammary Infections (IMI) Occurring During the Dry Period in Quarters Cultured Negative at Dry-off by Research Site Involved

Site	Ontario	Ontario	KS	NY	IA	Total
No. of new	18	11	29	24	17	99
Total quarters dry	161	99	288	180	264	992
% new IMI	11.2	11.1	10.1	13.3	6.4	9.9

Table 3. Logistic Regression Model for the Probability of a Cow Developing a New Intramammary Infection (IMI) During the Dry Period

Variable	β estimate	Std. error	P value	Odds ratio (95% CI)
Intercept	−1.320	1.250	0.30	
Breed	−0.070	0.210	0.73	
Site	−0.070	0.190	0.56	
Parity	0.070	0.180	0.72	
DIM	−0.002	0.002	0.41	
Milk >5 kg	1.200	0.650	0.06	3.3 (0.9-11.8)
	Deviance:	d.f.= 239		

BACTERIAL DEGRADATION OF MILK COMPONENTS IS AFFECTED BY STORAGE TEMPERATURE AND TIME

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Summary

Raw milk is an excellent medium for bacterial growth. The objective of this study was to evaluate the number of microbes and component degradation in raw milk. Milk fat content did not affect bacteria counts. As storage temperature or time increased, greater numbers of bacteria were present. In this study, milk protein was degraded preferentially over lactose or milk fat. As the milk storage temperature increased from 39 to 45°F, protein degradation became more pronounced. Milk fat remained relatively stable, though some degradation products were observed, especially after 4 days of storage at 39°F. Both milk fat and protein degradation can produce small, volatile compounds that negatively affect the flavor and odor of milk. Thus, to maintain high quality fluid milk in the market, milk must be available to the consumer soon after its processing.

(Key Words: Raw Milk Quality, Proteolysis, Lipolysis.)

Introduction

Milk production and processing facilities have become fewer in number and larger in size. These changes have forced raw milk to be transported further before processing and have prolonged the time until milk is consumed. Refrigerated conditions are mandated from on-farm milk storage until retail purchase, but microorganisms are able to replicate in both raw and pasteurized products that are refrigerated.

For many years, one of the greatest concerns of poor milk flavor quality was "acid" flavors. These acid flavors were the result of lactic acid bacteria that degraded lactose, eventually producing lactic acid. The "soured" milk could be smelled, tasted, and sometimes seen as clotted milk. Refrigeration has minimized the growth of lactic acid bacteria, but enhanced growth of microbes that tolerate colder temperatures. These cold-tolerant microbes (psychrotrophs) grow in raw and pasteurized milk, producing various enzymes and by-products that cause milk to have an off-flavor or odor at the processing facility or the consumers' home. Generally, these enzymes do not act on lactose to produce acid, but rather they act on fats and proteins, producing other compounds that generate off-flavors that may be just as undesirable as "sour milk." Thus, this study was undertaken to monitor the number of microbes and component degradation products in raw milk stored at 39° or 45°F for 1 week.

Procedures

Raw milk was obtained from the Kansas Dairy Research and Teaching Facility in Manhattan, KS. Two different milk samples were obtained, milk from a select group of cows that produced high fat milk; and milk from a group of cows that produced milk with normal fat percentages. Immediately after milking, milk was transferred to the K-State Dairy Processing Facility, filtered, sampled, then divided into whirl-pack bags, and placed at 39 or 45°F. Samples were removed for analyses every 2 days for up to 8 days.

Milk samples were analyzed for compositional analyses, total plate counts, psychrotrophic counts, pH, titratable acidity, proteolysis, and acid degree value following published, standardized methods. Compositional analyses were made to confirm the difference in milk composition and these tests were completed on day 1 only. Bacteria counts were monitored throughout storage. Total plate counts (TPC) were used as a quality index for fluid milk and as a decision tool for accepting raw milk into a fluid processing plant. Raw milk is not accepted into the fluid milk processing facility if TPC are >100,000 cfu/ml for a single producer and 300,000 cfu/ml for commingled milk. Psychrotroph counts provided an indication of the shelf life of pasteurized milk. Generally when counts were close to 1,000,000 cfu/ml, the milk has reached the end of its shelf life. Although the psychrotrophic bacteria are not considered to be harmful, their various enzymes catalyze the degradation of milk fat, protein, and lactose to such an extent as to render the milk to be "poor quality."

Throughout storage, titratable acidity (TA %) and pH were measured as an indication of lactose degradation. Proteolysis was monitored to determine if the protein was being degraded in the milk and acid degree value was measured to determine the extent of fat degradation in the milk. Because the milk was refrigerated, the lactose, protein, and fat degradation resulted from enzymes associated with the metabolic activities of the bacteria in the milk.

Results and Discussion

Table 1 shows the overall average composition and somatic cell counts of the two milk samples of different fat content (high vs. normal). Lactose contents of the two milk samples were similar as were protein contents. Higher fat content might provide greater amounts of substrate for lipolytic enzymes excreted from the bacteria. Somatic cell counts indicated that the normal fat milk sample had much higher SCC than did the higher fat milk sample.

Data for microbial counts of the two milk samples stored at the two temperatures are shown in Tables 2 and 3. Both milk samples stored at the higher temperature (45°F) had greater bacteria counts than those stored at 39°F. The composition of milk did not seem to affect the microbial growth. Because single-herd, raw milk with >100,000 cfu/ml is not accepted into a fluid milk plant, milk stored at 45°F would not be accepted on or after day 2. However, the milks stored at 39°F would have been accepted on day 2, but not on day 4 using the TPC standard only. The psychrotrophic bacteria counts showed similar trends -- higher counts for both milk samples stored at the higher temperature. However, a sharp decrease in counts was observed on day 8 for both milk samples and both storage temperatures. Overall, bacteria counts of the 45°F milk samples on day 4 and the 39°F milk samples on day 6 exceed the bacterial limits for even manufactured grade milk.

Data of the component degradation analyses showed that storage temperature and time affected the rate of biochemical reactions. Proteolysis results (Table 4) indicated that the milk stored at 45°F had almost twice the amount of protein breakdown products than milk stored at 39°F on day 8, with proteolysis starting to increase sharply by day 6. However, acid degree value data (ADV; Table 5) indicated that lipolysis or lipid degradation occurred at a faster rate in milk stored at 39°F than that stored at 45°F. Generally, an ADV >0.7 is an indication of lipid breakdown. Although milk did not reach that threshold during this study, the trend showed that lipid degradation did occur during the storage of these raw milk samples.

TA and pH values (Tables 6 and 7) showed little change during the 8-day storage period at either storage temperature, indicating that the lactose probably was not a substrate during these test conditions. Although complete degradation of milk lipids and proteins would generate some acids, it seemed that the generation of acids by these degradation pathways were not sufficient to cause a change in the TA or pH values in this study.

Table 1. Average Percentage of Fat, Protein, Lactose, and Solids-Not-Fat and Somatic Cell Counts (SCC) of Two Milk Samples of Different Fat Content

Fat content	Fat	Protein	Lactose	SNF[a]	SCC[b] (×1000)
High (n = 3)	3.85	3.15	4.75	8.84	247.8
Normal (n = 3)	3.46	3.03	4.79	8.75	749.4

[a]SNF = solids not fat. [b]SCC = somatic cell count.

Table 2. Means of Total Plate Counts (CFU/ml ×1000) of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	16.6	812.8	11,220	87,096	TNTC*
	39	6.91	34.8	141.2	109.7	1,023.3
Normal (n = 3)	45	34.7	1,479	15,488	34,673	TNTC*
	39	37.1	25.7	190.5	104.7	1,819

*To numerous to count.

Table 3. Means of Psychrotrophic Counts (CFU/ml ×1000) of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	9.5	562	5,623	40,783	5,495
	39	8.5	56.2	208	208	0.11
Normal (n = 3)	45	2.75	218.8	5,623	40,738	14,453
	39	9.8	6.9	70.8	323.6	3.23

Table 4. Means and Standard Deviations of Proteolysis Data (µmole/ml protein) of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	459.2 ± 82.1	438.0 ± 27.0	574.5 ± 39.5	838.5 ± 56.9	1117.25 ± 23.1
	39	459.2 ± 82.1	403.7 ± 26	464.5 ± 14.7	524.5 ± 63.6	578.0 ± 11.1
Normal (n = 3)	45	452.7 ± 90.0	432.2 ± 26.4	572.5 ± 96.3	770.7 ± 200	1193.5 ± 459.1
	39	452.7 ± 90.0	417.7 ± 23.5	457.0 ± 20.0	538.7 ± 44.2	630.7 ± 141.3

Table 5. Means and Standard Deviations of Acid Degree Values of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	0.24 ± 0.01	0.32 ± .04	0.35 ± 0.05	0.36 ± 0.01	0.29 ± 0.07
	39	0.25 ± 0.01	0.38 ± 0.02	0.49 ± 0.21	0.59 ± 0.09	0.45 ± 0.20
Normal (n = 3)	45	0.25 ± 0.04	0.29 ± 0.13	0.32 ± 0.11	0.39 ± 0.08	0.36 ± 0.14
	39	0.25 ± 0.04	0.38 ± 0.04	0.53 ± 0.27	0.56 ± 0.05	0.45 ± 0.10

Table 6. Means of pH Values of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	6.82	6.81	6.75	6.70	6.79
	39	6.85	6.81	6.77	6.73	6.80
Normal (n = 3)	45	6.82	6.80	6.79	6.75	6.85
	39	6.85	6.79	6.79	6.76	6.87

Table 7. Means and Standard Deviations of Titratable Acidity (Expressed as % Lactic Acid) of Two Milk Samples of Different Fat Content Stored at 39 or 45°F for 8 Days

Fat content	Temperature (°F)	Day 0	Day 2	Day 4	Day 6	Day 8
High (n = 3)	45	0.14 ± 0.01	0.13 ± .01	0.13 ± 0.0	0.13 ± 0.01	0.15 ± 0.00
	39	0.13 ± 0.03	0.13 ± 0.01	0.12 ± 0.00	0.13 ± 0.01	0.13 ± 0.01
Normal (n = 3)	45	0.13 ± 0.01	0.13 ± 0.01	0.13 ± 0.00	0.13 ± 0.01	0.15 ± 0.02
	39	0.13 ± 0.01	0.13 ± 0.01	0.13 ± 0.01	0.12 ± 0.00	0.15 ± 0.00

DRINKING WATER REQUIREMENTS FOR LACTATING DAIRY COWS

M. J. Brouk, J. F. Smith, J. P. Harner[1], and S. R. DeFrain

Summary

A study to determine the amount and location of water consumption in dairy free-stall barns located in northeastern Kansas was conducted during the summer of 2000. Three farms, two Holstein farms with either 2-row or 4-row freestall barns and one Jersey farm with 4-row freestall buildings, were used. Summer water usage averaged 30 to 40 gallons per Holstein cow/day and 20 to 40 gallons/cow/day for Jersey cows depending on age and stage of lactation. The farms with Holstein cows had a water usage ratio of 4 to 4.5 lb of water per lb of milk produced and Jersey cows required 3.1 lb of water per lb of milk production. However, at the Holstein dairies, only about 85% of this water was consumed and the other 15% was utilized to refill the tanks after tipping twice daily to clean cross-overs and water troughs. In addition, 35 to 45% of the water consumed is from a water station in the center crossover of each pen. Cattle also drank the least amount of water from the trough located in the crossover furthest from the pen entrance. When given access to a water trough on the milking parlor exit, cattle consumed 10% (3.5 gallons/cow/day) of the daily water intake at this location. Water usage for drinking increased as milk production increased. Adequate water system capacity and water rights are needed to make allowances for future increases in milk production. Water consumption was greater at the center alleys. Therefore, engineers should consider additional space and/or water troughs at these watering stations.

(Key Words: Water Consumption, Heat Stress, Cow Comfort.)

Introduction

Water consumption by dairy cows is related to feed intake, weather conditions, milk production, and stage of lactation. The ratio of drinking water to milk production is estimated at 4.5 to 5 lbs of water per lb of milk. Lactating milk cows drink from 30 to 50 gallons of water/day. Drinking water satisfies 80 to 90% of the daily water requirements of a dairy cow.

The objective of this study was to determine water usage during periods of heat stress and the impact of water trough location in a freestall.

Procedures

Three dairies were selected in north central Kansas for this study during the summer 2000. At the first dairy, Holstein cows were housed in a 4-row freestall barn, milked 2× and milk production averaged 72 lb/cow/day. Each pen contained 84 freestalls with a stocking density of 110%. Figure 1 shows the placement of the water troughs in the 4-row freestall building. Fans and a feedline sprinkler system were used for heat abatement. Walking distance from the back of the milk parlor to the housing area was less than 150 ft. Water space available was 3 cows per linear ft of trough.

At the second dairy, Holstein cows were housed in 2-row freestall buildings, milked

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3× and milk production averaged 78 lb/cow/day. Figure 2 shows the water trough location in the 2-row freestall facility. The milk parlor was a double 12 parlor with two exiting lanes. Water troughs were located on the east and west side of a common exit lane and were equipped with water meters. Cows had to walk 400 to 500 ft from the milking parlor to the freestall buildings. Each freestall had 108 freestalls and was stocked at 100% capacity. Water space available was 3.6 cows per linear ft.

The third dairy utilized Jersey cows producing an average of 65 lb of milk/cow/day. The herd was housed in a 4-row freestall barn and milked 2×. Building layout was similar to Figure 1 except the pens housed cows in different stages of lactation. Each pen housed 40 cows. The walking distance from the milking parlor to the freestall housing area was 30 ft. The water troughs were not emptied on a routine basis for cleaning at this dairy.

Water meters recorded water consumption at each water trough during the summer of 2000. Data were collected from mid June until the end of August. Meters were read approximately every 2 weeks. The water usage data included the amount of water used to refill the water troughs after dumping at the Holstein dairies. It was assumed the troughs were dumped twice a day as the cows were being milked at the two Holstein farms.

The water for all dairies was supplied from deep wells. Each water trough was connected to the main distribution line using a ¾-inch hose. Each water trough held approximately 100 gallons. The water temperature was not recorded during the study period.

Results

Water usage at the first dairy (Figure 3) averaged 35.1 gallons/cow/day including the water used to refill the tanks after dumping. Figure 4 shows the water usage in each of the four pens. Higher producing cattle were located in the SW and NE pens. Over 40% of the water was consumed from the water trough located in the center cross alley (Figure 5). The water trough located farthest from the travel lane to the milk parlor had the lowest usage. Approximately 4.8 gallons/cow/day were needed to refill the water tanks after tipping. This represented 14% of the total daily usage in the freestall housing area, excluding water used for heat abatement.

Figure 6 shows the daily water usage for the 2-row freestall buildings located on the second dairy. Data from the north pen more accurately reflected the water usage of this herd at 40.2 gallons/cow/day plus an additional 3.5 gallons/cow/day at the milk parlor water tank. Data from the south pen shows the impact of a leaking water line (Figure 7). Average water usage per cow increased from 40.2 to 58.9 gallons/cow/day. This represented nearly a 50% increase in water consumption during the study period. Figure 7 shows the water usage at the individual water troughs in the north and south buildings. The water meter reveals the impact of the leaking water line at the water trough farthest from the travel lane in the south building. Water usage at the center water trough and water trough near the travel lane were similar. Approximately 6.7 gallons/cow/day were used in refilling the tanks after tipping. This represented 15% of the total daily water usage in the housing area.

Figure 8 shows the water usage at the water troughs located in the milk parlor exit lanes at the second Holstein farm. There was no difference between the usages of water in the west or east exit parlor lane. The total water usage at the exit lane was approximately 3.5 gallons/cow/day or about 8% of their daily consumption.

The third site showed that Jersey cows required significantly less water. Data collected during the summer of 2000 found late lactation cows, early-lactation cows and 2-year-old heifers drank 20, 24.5, and 21.4 gallons/cow/day, respectively. Because the tanks were not routinely tipped for cleaning, this was more representative of the actual water consumed by the cows.

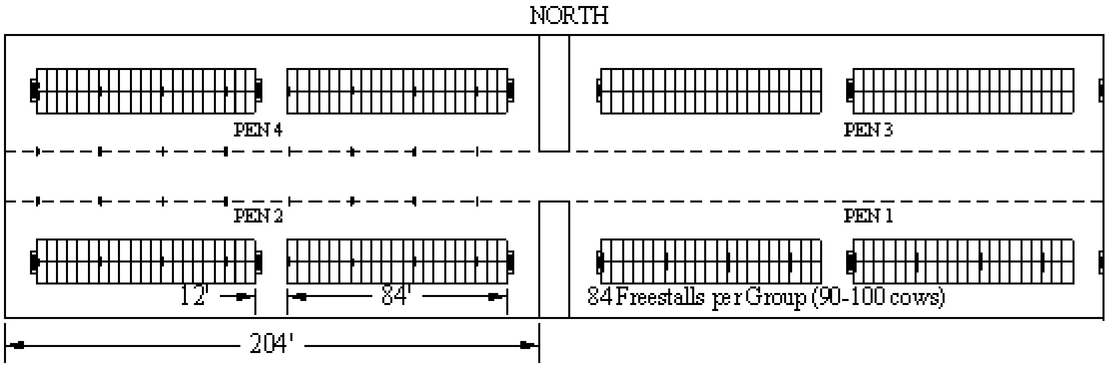
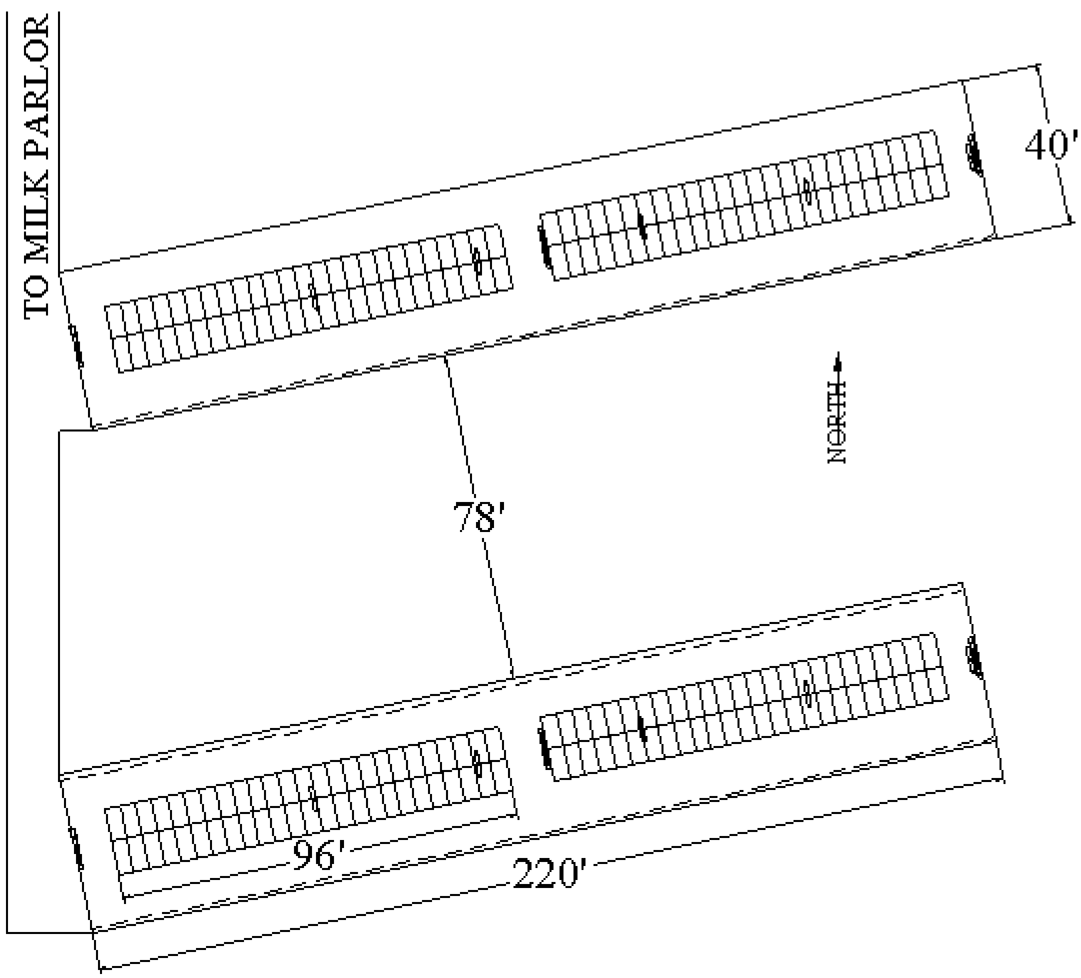


Figure 1. Layout of Pens and Location of Water Troughs ✉ in a 4-Row Freestall Building.

Figure 2. Layout of 2-Row Freestall Buildings and Location of Water Troughs ✉.



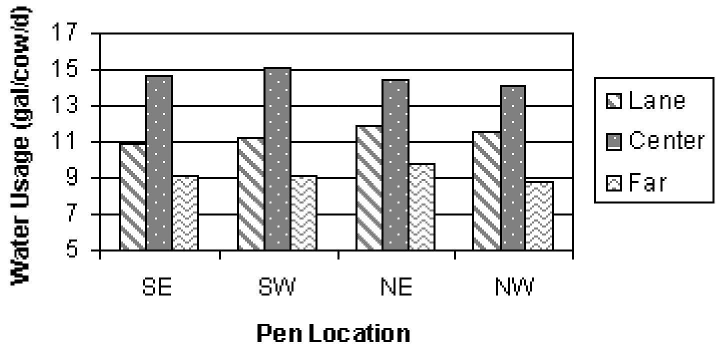


Figure 3. Total Daily Water Disappearance from Water Troughs in Different Pens in a 4-Row Freestall Building Populated with Holstein Cows.

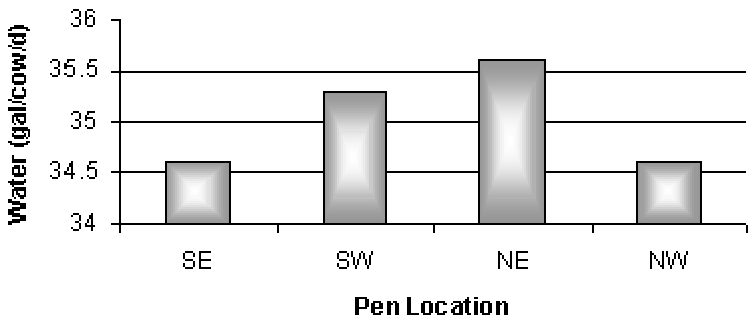


Figure 4. Water Disappearance from Water Troughs Located in Different Sections of a 4-Row Freestall Building Populated with Holstein Cows.

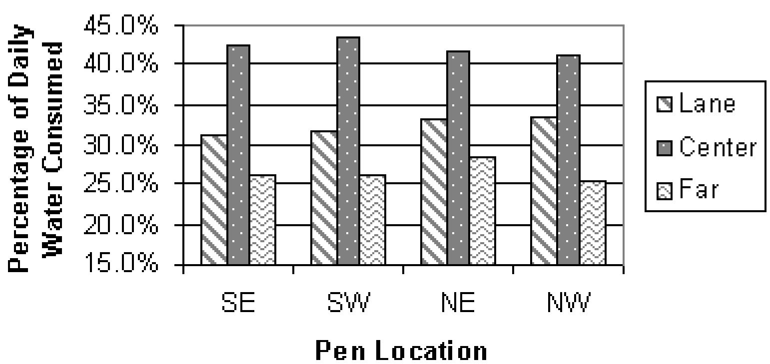


Figure 5. Percent Water Disappearance from Water Troughs Located in Different Sections of a 4-Row Freestall Building Populated with Holstein Cows.

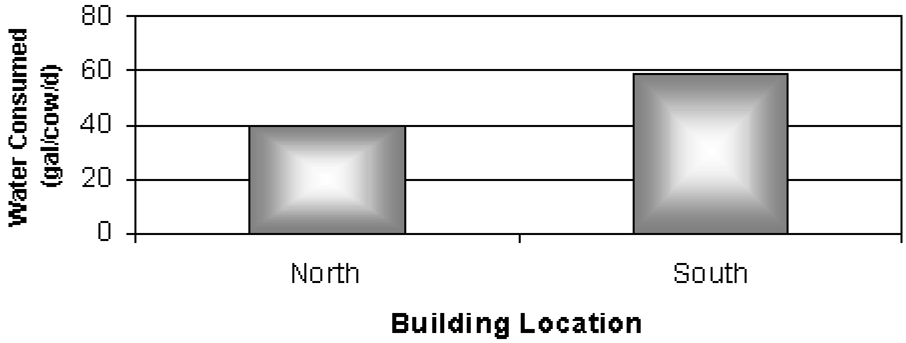


Figure 6. Total Daily Water Disappearance in 2-Row Freestall Buildings Populated with Holstein Cows.

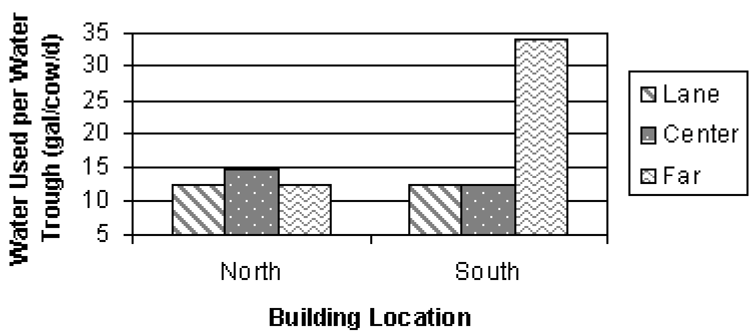


Figure 7. Water Disappearance from Water Troughs Located in Different Sections of a 2-Row Freestall Building Populated with Holstein Cows.

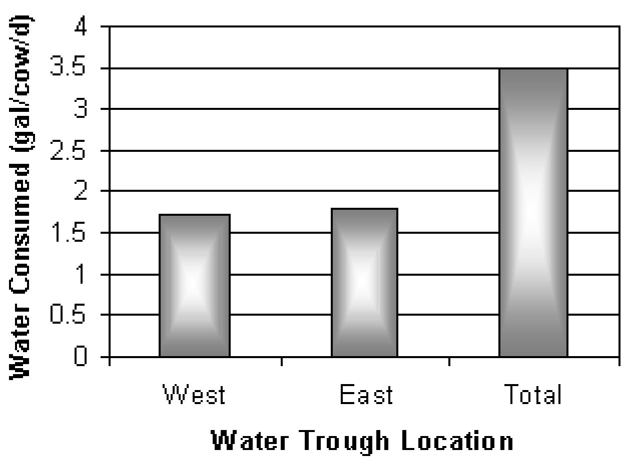


Figure 8. Water Consumed by Holstein Cows at Water Troughs Located at Milk Parlor Exit.

EFFECTS OF A BIOLOGICAL ADDITIVE AND SEALING TECHNIQUE ON THE AEROBIC STABILITY OF WHOLE-PLANT CORN SILAGE

M. E. Uriarte, K. K. Bolsen, and R. V. Pope

Summary

The objectives of this whole-plant corn study were to determine the effects of a biological additive and sealing technique on yeast and mold populations; and to examine the relationship between the microbial and chemical changes in the silages during exposure to air. Whole-plant corn was harvested at 80% milkline (36% DM), and ensiled at a density of 43 lb of fresh matter/ft^3. One-half of the pre-ensiled forage was treated with a biological additive (A), which contained a mixture of bacteria and enzymes (supplied by Alltech, Inc., Nicholasville, KY); the other one-half of the pre-ensiled forage was the untreated control (C). One-half of the silos in the A and C groups were sealed immediately after filling (S = sealed) and the remaining silos were sealed 48 hr after filling (DS = delayed seal). Treatments consisted of combinations of the two main effects: additive (A and C) and sealing technique (S and DS). There were three, 5-gallon capacity, laboratory silos per treatment. Silos were opened after 150 days, and the chemical and microbial compositions and aerobic stability of the silages determined. All four silages were moderately stable during the period of exposure to air. The C, DS silage was the first to show a rise in temperature, occurring after 65 hr of exposure to air. The two DS silages were 48 hr less stable than their S counterparts, and the two A silages were 24 hr more stable than their C counterparts. Deterioration of the silages during exposure to air was accompanied by an increase in temperature and pH, a decrease in lactic acid content, and a rapid increase in the lactate-assimilating yeast population. Treatment with a biological additive significantly improved aerobic stability, but the mechanism of action was not evident. Delayed sealing after the silos were filled reduced the aerobic stability of the silages.

(Key Words: Corn Silage, Aerobic Deterioration, Silage Additives.)

Introduction

Efficient forage preservation as silage requires minimizing losses during the aerobic, fermentation, storage, and feedout phases. Although the efficiency of the fermentation phase has improved during recent years, the same cannot be said about aerobic stability during the feedout phase. Well-preserved silages are often more prone to aerobic deterioration than their poorly preserved counterparts.

The addition of homofermentative lactic acid bacteria (LAB) has improved silage quality by promoting a fast and efficient production of lactic acid that results in a rapid decrease in pH. This has not necessarily improved aerobic stability at feedout because aerobic stability has often been less for homolactic compared to heterolactic silages.

Enzymes have been used for years as silage additives; and the most common enzymes are cellulases, hemicellulases, xylanases, pectinases, and amylases. Enzymes breakdown complex polysaccharides (fiber and starch) to simple sugars, which provide LAB with more substrate for the production of lactic acid, but enzymes have had variable and inconsistent effects on aerobic stability.

The objectives of this study with whole-plant corn were to determine the effects of a biological additive and sealing technique on yeast and mold populations; and to examine the relationship between the microbial and chemical changes in the silages during exposure to air.

Materials and Methods

Silage Preparation. Whole-plant corn was harvested at 80% milkline (36% DM) on September 21, 1999. It was precision chopped to a 0.5-inch theoretical particle size, ensiled in laboratory silos, and packed at a density of 43 lb of fresh forage per cubic foot. One half of the pre-ensiled forage was treated with a biological additive (A) that contained a mixture of bacteria (e.g., *Streptococcus faecium*, *Pediococcus acidilactici*, *Lactobacillus plantarum*, *Bacillus pumulis*) and enzymes (e.g., cellulase, hemicellulase, amylase, and pentosanase) (provided by Alltech, Inc., Nicholasville, KY). The other half of the pre-ensiled forage was the untreated control (C). One-half of the silos in the A and C groups were sealed immediately after filling (S = sealed), and the other half sealed 48 hr after filling (DS = delayed sealed).

The laboratory silos were 5-gal capacity plastic pails. Silos were filled using a hydraulic press and fitted with a Bunsen valve to allow gases to escape. Treatments consisted of combinations of the two main effects: additive (A and C) and sealing technique (S and DS).

Aerobic Stability Measurements and Silage Composition. The silos were opened after 150 days. All three replicates from each treatment were mixed and sampled. The composited and mixed, and pooled samples for each treatment were placed in 1.7-gal capacity polystyrene foam containers. There were 10 containers per treatment, and the silages were exposed to air for 6 days. Thermocouples were placed in the center of the silage in each container, and temperature of silages was recorded daily at 06, 12, 18 and 24 hr. Ambient room temperature was kept constant at 24°C ± 0.5. A silage was considered aerobically unstable when the temperature raised 1.5°C above room temperature. Two containers of each treatment were removed on days 1 through 4, and two samples were taken: one was frozen for further chemical analysis (e.g., pH, DM, lactic acid, and volatile fatty acids) and the other analyzed immediately for microbial counts (e.g., lactic acid bacteria, yeast and mold, and lactate assimilating yeast).

Statistical Analysis. The treatment structure was a two-way with no independent replications of the two-way treatment combinations. Data on chemical composition and microbial counts were analyzed by the GLM and Mixed procedures of SAS using techniques for non-replicated experiments. Results are reported as least-square means. Observed differences were considered to be significant at $P \leq 0.05$.

Results

The chemical composition of the corn silages after 150 days of storage and a 6-day exposure to air is shown in Table 1. Silage pH and lactic and acetic acid concentrations indicated efficient preservation. Exposure of the silages to air led to an increase in pH and a decrease in lactic and acetic acid contents in the delayed seal silages.

All four corn silages were moderately stable during the exposure to air (Figure 1). The first increase in temperature occurred after 65 hr in the control silage where sealing was delayed (C, DS), and the additive-treated, delayed seal silage (A, DS) was the next to heat (after 89 hr). Extremely good aerobic stability was observed in the two sealed silages. The C, S silage was aerobically stable for 113 hr; the A, S silage was stable for 137 hr. The two DS silages were 48 hr less stable than their S counterparts, and the two A silages were 24 hr more stable than their C counterparts.

The effect of sealing technique on pH changes in the corn silages during exposure to air is shown in Figure 2. The pH of the C, DS silage increased dramatically from day 2 to 3, whereas pH of the A, DS silage increased from day 3 to 4 (data not shown). Both sealed silages remained aerobically stable throughout the first 4 days of exposure to air, with pH values of 3.5 for the control silage and 3.7 for the additive-treated silage.

Lactic acid content of silages was affected by interactions ($P<0.05$) between sealing technique and time of exposure to air ($P<0.05$) (Figure 3) and between sealing technique and additive (Figure 4). Lactic acid content in the delayed sealed silages decreased dramatically from day 2 to 3 of exposure to air. The lactic acid content in the sealed silages did not change throughout the 4-day exposure to air. The C, S silage had a much higher acetic acid content than it's a, S silage counterpart (Table 1). Sealed and delay sealed additive-treated silages had numerically similar lactic and acetic acid values.

The microbial composition of the corn silages after 150 days of storage and a 4-day exposure to air is presented in Table 2. Additive and sealing technique had no significant effects on yeast and mold populations. Most of the yeast were lactic acid-assimilating yeasts (LAY) and counts at day 0 ranged 10^2 to 10^5 cfu per g of silage (fresh basis). Aerobic deterioration of the two delayed seal silages was accompanied by an increase ($P=0.06$) in the LAY population (Figure 4). The increase in LAY during exposure to air also was accompanied by increases in temperature and pH and a decrease in the lactic acid content of the silages.

Conclusions

The biological additive and delayed sealing had clear effects on the aerobic stability of the corn silages. Treatment with a biological additive significantly improved aerobic stability, but the mechanism of action was not evident. Delayed sealing after the silos were filled reduced the aerobic stability of the silages. The S silages were 48 hr more aerobically stable than their DS counterparts, and the two A silages were 24 hr more stable than their C counterparts.

Silage management practices that eliminate the presence of air should minimize the active role played by aerobic microorganisms in the deterioration process. More care should be taken to reduce air infiltration by timely and proper sealing, and maintenance of the quality of the seal. The effects of homolactic bacterial inoculants and enzymes on the aerobic deterioration process is not clear or consistent, and factors other than air *per se* need to be studied.

Table 1. pH and Chemical Composition of the Four Corn Silages Before (Day 0) and After Exposure to Air (Day 4)

	pH		Lactic acid[1]		Acetic acid[1]	
	Day		Day		Day	
Treatment	0	4	0	4	0	4
Control[2]						
S (35.1)	3.7	3.6	4.5	4.4	2.4	0.2
DS (33.8)	3.7	8.0	4.9	0.3	1.4	ND
Additive[2]						
S (33.0)	3.5	3.7	4.1	3.9	1.4	0.2
DS (32.5)	3.6	8.2	4.5	1.5	1.5	ND

[1]Percent of the silage DM.

[2]Percent of the DM of the corn silages is shown in parenthesis.
ND = not detected.

Table 2. Microbial Composition (Log CFU per g of Fresh Material) of the Corn Silages Before (Day 0) and After Exposure to Air (Day 4)

	Yeast and Mold		Lactate Acid-Assimilating Yeast	
	Day		Day	
Treatment	0	4	0	4
Control				
S	NA	9.2	4.9	8.2
DS	2.9	9.7	5.7	9.4
Additive				
S	NA	9.1	5.0	9.0
DS	5.1	8.6	5.5	8.7

NA = sample not analyzed.

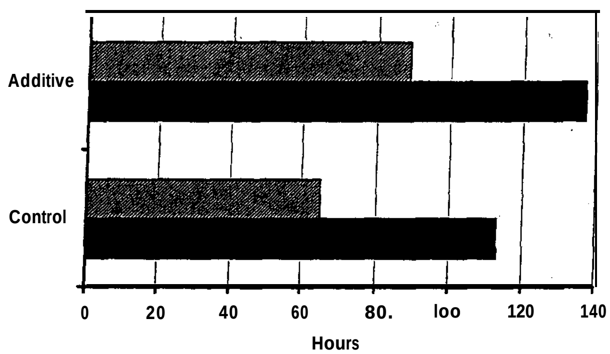


Fig. 1. Hours to the Initial Rise in Temperature for the Four Corn Silages during Exposure to Air. ☐ Sealed, ☒ Delayed seal

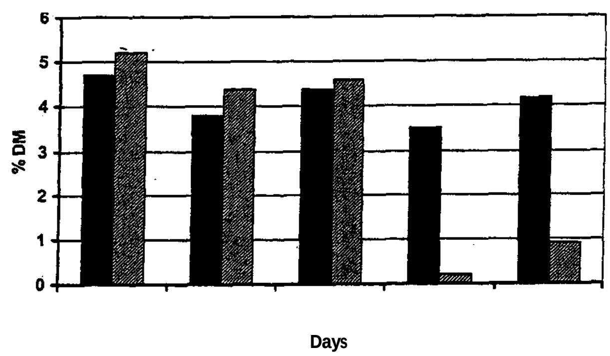


Fig. 3. Lactic Acid Changes (% of the silage DM) in the Corn Silages during Exposure to Air: Effect of Sealing Technique. ☐ Sealed, ☒Delayed seal

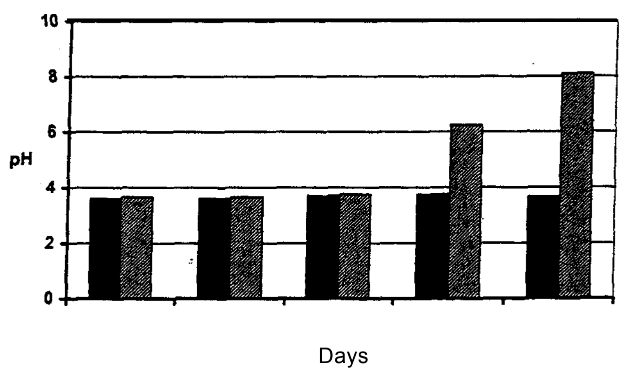


Fig. 2. pH Changes in the Corn Silages during Exposure to Air: Effect of Sealing Technique. ☐ Sealed, ☒ Delayed seal

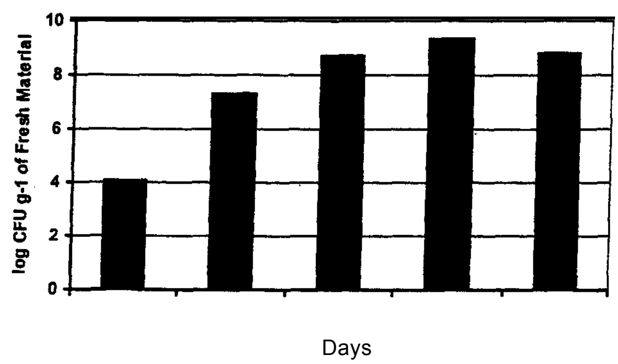


Fig. 4. Lactic acid-assimilating yeast populations in the corn silages during exposure to air.

PERFORMANCE OF HOLSTEIN COWS FED WET CORN GLUTEN FEED OR SOYHULL-STEEP LIQUOR PELLETS DURING EARLY LACTATION

E. E. Ferdinand, J. E. Shirley, E. C. Titgemeyer, A. F. Park, and J. M. DeFrain

Summary

Wet corn gluten feed and soyhull-steep liquor pellets tended to increase dry matter intake and milk yield. Combining condensed corn steep liquor with raw soybean hulls provides a convenient source of digestible fiber and rumen degradable protein.

(Key Words: Wet Corn Gluten Feed, Dairy, Soyhulls, Corn Steep Liquor.)

Introduction

Complete lactation milk yield is positively related to peak milk yield, which generally occurs by 50 to 60 days in milk. Nutrition limits peak milk yield because of inadequate dry matter intake. Body tissue mobilization and ruminal adjustments are made in an attempt to meet nutrient deficits. Therefore, it is imperative during early lactation to provide dietary ingredients that are highly digestible in order to enhance nutrient availability. A critical issue in diet formulation is balancing fiber content to prevent ruminal acidosis. Short-term studies (28-day period) conducted at Kansas State University with wet corn gluten feed (WCGF) and a pelleted feedstuff made by combining soy hulls and condensed corn steep liquor (SHSL) indicated that these feedstuffs improve dry matter intake and maintain ruminal pH. The purpose of this study was to evaluate the response of dairy cows to WCGF and SHSL during the first 90 days in milk.

Procedures

Forty-six multiparous Holstein cows were used in a randomized incomplete block design. Cows were blocked on calving date and assigned randomly to either of three diets: 1) control, 2) wet corn gluten feed at 20% of dry matter; or 3) soy hull-steep liquor pellet at 20% of dry matter. Treatment diets were balanced for previous lactation milk yield, body weight, and body condition score as much as possible. Wet corn gluten feed (WCGF) replaced 10, 5, and 5% of the alfalfa hay, corn silage, and corn grain in the control diet (DM basis), respectively and soy hull-steep liquor (SHSL) replaced 10, 5, 2, and 3% of the alfalfa hay, corn silage, corn grain, and solvent soybean meal in the control diet (DM basis), respectively. Treatment diets were initiated beginning at the first feeding after calving and fed ad libitum twice daily as a total mixed ration. Feed ingredients were collected weekly and composited monthly for analyses. Individual feed intakes and milk yield were measured daily. Milk samples (am and pm composite) were analyzed weekly for milk composition. Protein, fat, lactose, solids-not-fat, milk urea nitrogen (MUN), and somatic cells were measured by the Heart of America DHI Laboratory, Manhattan. Cows were weighed within 24 hr after calving and on two consecutive days weekly thereafter. Body condition was scored weekly.

Results and Discussion

The experimental diets and their composition are shown in Table 1. Diets containing WCGF or SHSL provided more neutral-detergent fiber (NDF) than the control diet and SHSL increased the dietary acid-detergent fiber (ADF) relative to the other diets. Cows fed diets containing WCGF or SHSL tended to consume approximately 3 to 4 lb more dry matter, respectively, than cows fed the control diet. The increase in dry matter intake tended to increase daily milk yield by approximately 8 to 9 lb for cows fed WCGF or SHSL, respectively, than those fed the control diet. Peak milk yield and days to peak milk yield prior to rbST administration (9th week of lactation) was 112, 44; 116, 46; 119, 39 for cows fed the control, WCGF, and SHSL diets, respectively.

Milk from cows fed the control diet contained more (P<0.05) than fat (4%) than cows fed the other diets (3.7%), but fat yield (lb/day) was similar for all diets due to the difference in milk volume. Milk protein percentage was similar but protein yield tended to increase with milk volume. Energy corrected milk divided by dry matter intake (ECM/DMI) provides a gross measure of efficiency. During the first 90 days in milk, cows usually have a relatively high ECM/DMI value (>1.5) because they mobilize fat to support milk production. All cows in our study seemed to be very efficient but efficiencies were not different among diets. Loss in body weight was unaffected by diets but cows fed the control diet tended to have less condition at the end of the first 90 days in milk.

In summary, WCGF and SHSL pellets tended to increase dry matter intake and milk yield. Combining condensed corn steep liquor with raw soybean hulls provides a convenient source of digestible fiber and rumen degradable protein.

Table 1. Composition of Experimental Diets

Ingredient	Diet		
	Control	WCGF[1]	SHSL[2]
	% of dry matter		
Alfalfa hay	30.00	20.00	20.00
Corn silage	15.00	10.00	10.00
Corn grain	32.00	27.00	30.17
WCGF	-	20.00	-
SHSL	-	-	20.00
Whole cottonseed	9.30	9.30	9.30
Soybean meal	4.39	-	1.40
Soybest	3.30	7.71	3.32
Fish meal	1.30	1.31	1.31
Molasses	1.00	1.00	1.01
Dicalcium phosphate	0.88	0.59	0.18
Limestone	1.36	1.54	1.62
Sodium bicarbonate	0.75	0.75	0.67
Magnesium oxide	0.21	0.21	0.22
Trace mineralized salt[3]	0.32	0.32	0.32
Vitamin ADE premix[4]	0.11	0.11	0.11
Vitamin E premix[5]	0.02	0.02	0.02
Sodium selenite	0.01	0.01	0.01
Nutrient			
Crude protein, %	18.53	18.28	19.06
RUP, (% of CP)	6.86	7.19	7.32
ADF, %	18.54	17.01	20.51
NDF, %	27.30	29.77	29.49
NE_L, Mcal/lb	0.77	0.80	0.79
NFC[6]	40.99	39.48	39.01
Calcium, %	1.38	1.43	1.14
Phosphorus, %	0.66	0.75	0.60
Sulfur, %	0.20	0.25	0.25

[1]Wet corn gluten feed. [2]Soyhull steep liquor: pellet containing 75% raw soybean hulls, 25% condensed corn steep liquor (DM basis). [3]Compositions: not less than 95.5% NaCl, 0.24% MN, 0.24% Fe, 0.05% Mg, 0.032% Cu, 0.032% Zn, 0.007% I, and 0.004% Co. [4]Contributed 5,733 IU of vitamin A, 2,866 IU of vitamin D, 17 IU of vitamin E per kg of diet DM. [5]Contained 600 mg of Se per kg premix. [6]NFC = 100 – (%NDF + %CP + % Ether Extract + %Ash).

Table 2. Effects of Diet on Performance during the First 90 Days in Milk

	Diet			
Item	Control	WCGF	SHSL	SEM
Dry matter intake, lb/day	51.3	54.6	55.1	2.0
Milk yield, lb/day	90.1	97.6	98.9	4.3
Peak milk yield, lb	111.8	116.5	119.1	4.6
Days to peak milk yield	43.9	46.5	38.8	3.6
Milk protein, %	3.0	3.0	3.0	0.1
Milk protein yield, lb/day	2.7	2.9	2.9	0.2
Milk fat, %	4.0[a]	3.7[b]	3.7[b]	0.1
Milk fat yield, lb/day	3.6	3.6	3.7	0.2
Milk urea nitrogen, mg/dL	14.6	14.7	14.8	0.5
ECM, lb/day[1]	94.1	98.2	100.2	1.9
ECM/DMI[2]	2.0	1.9	1.9	0.1

[a,b]Means within a row not bearing common superscripts differ (P<0.05).

[1]ECM = energy corrected milk, (0.327*milk kg) + (fat kg*12.95) + (protein kg*7.2).
[2]Energy corrected milk divided by dry matter intake.

Table 3. Effects of Diet on Body Weight and Condition[1]

	Diet			
Item	Control	WCGF	SHSL	SEM
Body weight initial, lb	1613	1583	1571	22.47
Body weight final, lb	1394	1413	1354	17.0
BCS initial[2]	3.0	3.2	3.0	0.1
BCS final[2]	2.7[a]	2.8[b]	2.8[b]	0.1

[a,b]Means within a row not bearing common superscripts differ (P=0.08).

[1]Initial body weight and BCS measured within 24 hrs after calving, final body weight, and BCS measured on day 90 and 91 after calving.
[2]BCS = body condition score.

CHANGES IN RUMEN CAPACITY OF DAIRY COWS DURING THE PERIPARTURIENT PERIOD

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Summary

Four-ruminally fistulated, multiparous, pregnant Holstein cows were studied to characterize ruminal adaptations during the transition from gestation to lactation. Cows were fed typical far-off and close-up diets, a late lactation diet containing wet corn gluten feed (20% DM), and an alfalfa hay, corn silage based early lactation diet. Ruminal measurements were obtained 72 (late lactation), 51 (far-off dry), 23 and 9 (close-up dry) days before expected parturition and 6, 20, and 34 days postpartum. Measurements included total fill, dry matter fill, fluid fill, and water-holding capacity of the rumen. Dry matter intake and milk production data were collected daily and body weight and body condition were determined weekly. Body weights and condition increased during the dry period, whereas intake as a percentage of body weight decreased. Ruminal water holding capacity, an indicator of rumen capacity, increased linearly from late lactation to 34 days postpartum. These data suggest rumen capacity is not the causative factor of intake depression in dairy cows during the final 3 wk of gestation.

(Key Words: Rumen Capacity, Dairy, Periparturient.)

Introduction

Dry matter intake generally decreases by 20 to 30% in dairy cows during the last 3 wk before parturition. This decrease in intake coincides with increasing feto-placental weight and is thought to be partly due to a decrease in rumen capacity because of space limitations in the abdominal cavity. Physical measurements of the space available in the abdominal cavity obtained from frozen cross sections of pregnant and nonpregnant cows indicated a decrease of 30% due to the presence of the fetus, placenta, and associated fluids. The problem with this technique is that it does not account for the expandability of the abdominal cavity or repositioning of the uterus. The purpose of our study was to measure changes in rumen capacity and function in vivo during late gestation and early lactation in Holstein cows in order to determine if the observed decrease in dry matter intake is associated with decreased rumen capacity.

Procedures

Four-ruminally fistulated, multiparous, pregnant Holstein cows were utilized in this study. The cows were impregnated to sires of similar calving ease and had similar projected calving dates, body weights, body condition scores, previous 305-day mature equivalent milk yields, and frame sizes (Table 1). Frame size was defined using hip and wither height as well as width between the hooks. Cows were housed in a tie-stall barn during an experiment that was initiated 94 days before calving and terminated 34 days after calving. Cows were fed typical late lactation, far-off, close-up, and early lactation diets (Table 2). Daily feed intakes and milk weights were recorded for individual cows. Body weights and condition scores were determined weekly.

[1]Department of Diagnostic Medicine and Pathobiology.

Ruminal total fill, dry matter (DM) fill, liquid fill, and water holding capacity were determined on days 72 (late lactation), 51 (far-off dry), 23 and 9 (close-up dry) prepartum and 6, 20, and 34 days postpartum. Ruminal water holding capacity was defined as the weight of water removed from a rumen filled with water to a pre-set mark on an air outlet hose and was assumed to estimate rumen capacity. The pre-set mark on the air outlet hose was aligned with the topline of the cow. Liquid fill represents the difference between total fill and DM fill. On sample days, rumens were emptied, contents weighed, and sampled in triplicate for dry matter determination. Rumens were then rinsed and filled with water to a pre-set mark on an air outlet hose. At this point the scales were zeroed and the water removed from the rumen was weighed.

Table 1. Initial Characteristics of Animals

Item	Mean	SE
BCS	2.63	0.16
BW, lb	1341.0	181.0
305-2X-ME milk, lb	23084.0	1244.0
Parity	2.0	0.0
Hook to hook, inch	22.1	2.0
Hip height, inch	55.1	0.8
Wither height, in.	54.3	0.9

Results and Discussion

The initial characteristics of the study cows are presented in Table 1. Cows of similar size, condition, bodyweight, and milk production potential were selected to reduce variation in the pre-determined measurements. The cows were impregnated to sires of similar calving ease scores (9.8 ± 0.2%) and projected calving dates (± 4 days). The average birth weight of the calves was 80.8 ± 10.3 lb and the cows calved between December 21 and 29, 2000. None of the cows experienced health disorders during the experimental period and milk yield reached 88 lb by day 34 of lactation. All cows were offered a common total mixed ration (TMR) consistent with their state of lactation or gestation (Tables 2 and 3).

The cows gained approximately 132 lb of body weight and their BCS increased from 2.43 ± 0.21 to 2.94 ± 0.21 between days 72 and 9 prepartum. Dry matter intake expressed as a percentage of body weight (Figure 1) decreased during this time but nutrient intake was sufficient to support fetal growth and improve nutritional status as evidenced by the increase in body weight and condition score. Ruminal dry matter fill exhibited the same pattern as dry matter intake on a percentage of body weight basis.

Rumen water holding capacity increased linearly ($P<0.01$) from late lactation to early lactation (Figure 2), which clearly refutes the theory that the observed decrease in dry matter intake prepartum is due to a decrease in rumen capacity. These results indicate that the expandability of the abdominal cavity is sufficient to accommodate the developing fetus without unduly restricting rumen capacity.

Evidence that rumen capacity does not restrict intake is further supported by the fact that ruminal dry matter fill expressed as a percentage of rumen water holding capacity decreases prepartum and increases postpartum (Figure 3). Dietary neutral detergent fiber (NDF) content has been advanced as a regulator of dry matter intake. Our results do not support this concept because NDF intake expressed as a percentage of rumen water holding capacity increased when cows consumed the high NDF far-off diet, whereas dry matter intake decreased (Figure 4). Intake of NDF mimicked DMI when cows consumed the close-up and lactation diets. In summary, the depression in dry matter intake observed prepartum is not due to limited rumen capacity.

Table 2. Experimental Diets

	Diets (% of DM)			
Item	Late Lact.	Far-off	Close-up	Early Lact.
Alfalfa hay	20.0	0.0	15.0	30.0
Prairie hay	0.0	48.4	20.0	0.0
Corn silage	10.1	19.8	30.0	15.0
Corn grain	27.7	22.4	18.7	32.0
Whole cottonseed	9.3	0.0	0.0	9.3
Fishmeal	1.3	0.0	0.0	1.3
Expeller soybean meal	7.7	0.0	9.4	3.3
48% soybean meal	0.0	8.4	4.4	4.4
Wet corn gluten feed	19.6	0.0	0.0	0.0
Molasses	1.3	0.0	0.0	1.0
Limestone	1.38	0.06	0.60	1.36
Dicalcium phosphate	0.05	0.40	0.74	0.88
Sodium bicarbonate	0.68	0.00	0.00	0.75
Trace mineral salt[1]	0.29	0.34	0.50	0.32
Magnesium oxide	0.20	0.00	0.50	0.21
Vitamin A,D, E[2]	0.12	0.11	0.12	0.13
Sodium selenite premix[3]	0.08	0.02	0.04	0.01

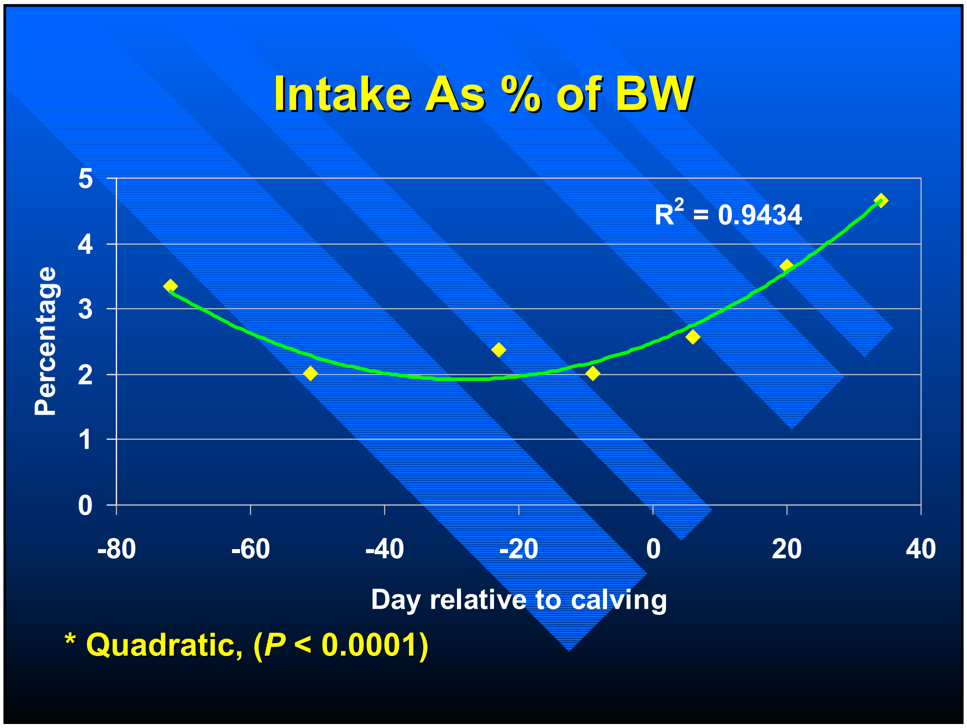
[1]Composition: not less than 95.5% NaCl, 0.24% Mn, 0.24% Fe, 0.05% Mg, 0.032% Cu, 0.032% Zn, 0.007% I, and 0.004% Co.

[2]Contributed 4912 IU vitamin A, 2358 IU vitamin D, and 24 IU vitamin E per kg diet DM.
[3]Contributed 0.06 mg Se per kg diet DM.

Table 3. Chemical Characteristics of Experimental Diets

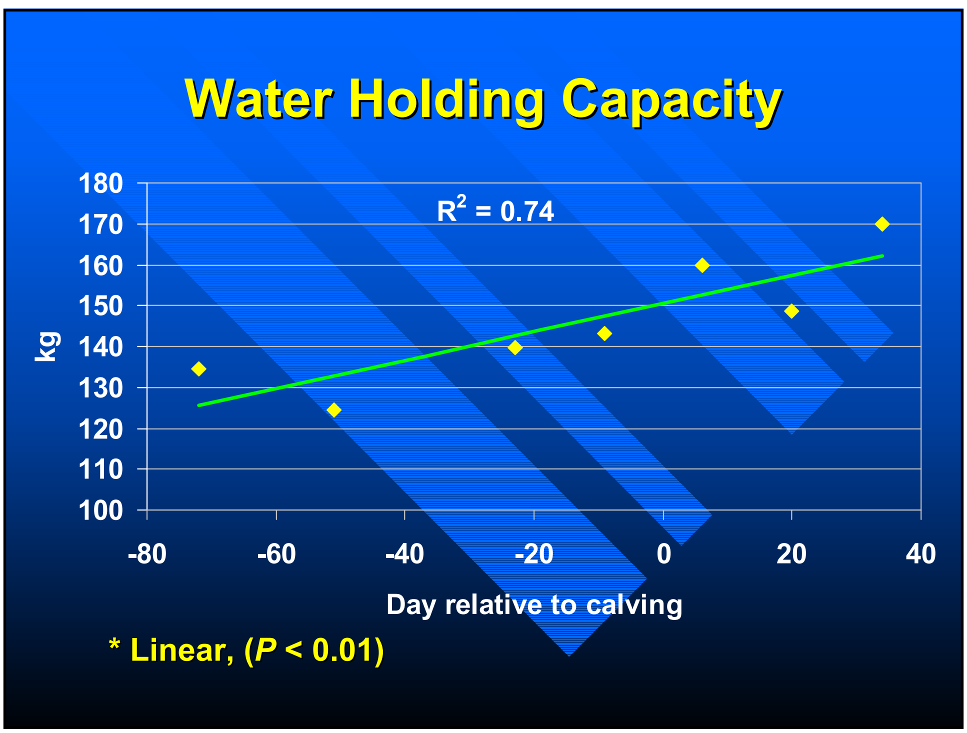
	Diets			
Item	Late Lact.	Far-off	Close-up	Lactation
Dry matter, %	75.25	82.46	76.87	82.50
Crude protein, %	18.68	11.47	15.57	18.38
Soluble protein, %	31.31	25.18	25.18	31.32
RDP, % of DM[1]	62.09	63.44	65.75	63.37
ADF, %	17.45	25.15	22.01	18.18
NDF, %	29.94	42.88	34.42	26.97
Non-fiber carbohydrate, %	37.84	35.16	39.12	40.44
NE_L , Mcal/kg	1.73	1.46	1.56	1.70
Crude fat, %	5.75	3.76	3.49	5.60
Ash, %	7.70	6.72	7.40	8.43
TDN, %	73.24	67.02	69.08	72.25
Calcium, %	1.07	0.52	0.81	1.51
Phosphorus, %	0.66	0.36	0.49	0.71
Magnesium, %	0.34	0.20	0.35	0.33
Potassium, %	1.41	1.15	1.49	1.48
Sodium, %	0.37	0.11	0.17	0.33
Sulfur, %	0.25	0.13	0.17	0.21

[1]Based on feed analysis from Dairy Herd Improvement Forage Testing Laboratory (Ithaca, NY).



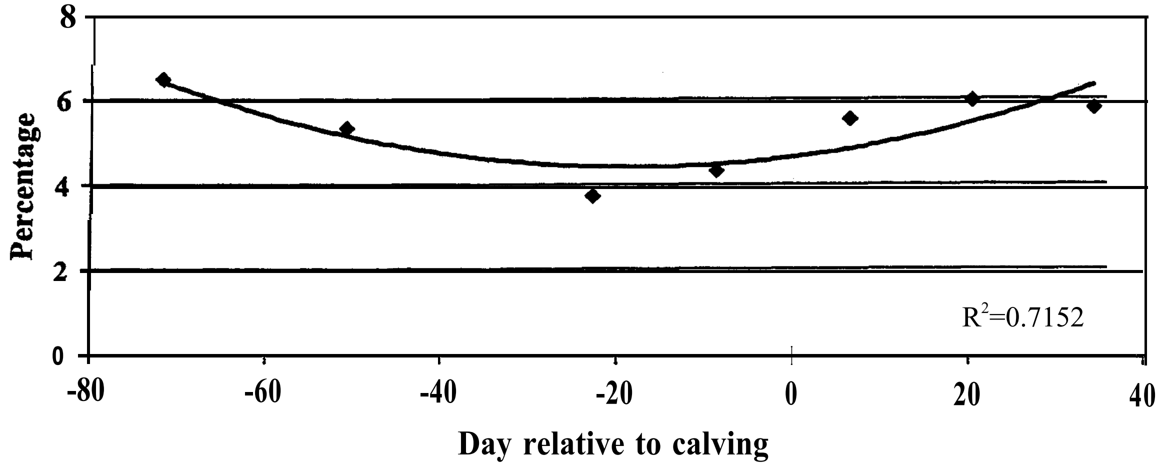
SEM = 0.28.

Figure 1. Dry Matter Intake as a Percentage of Body Weight.



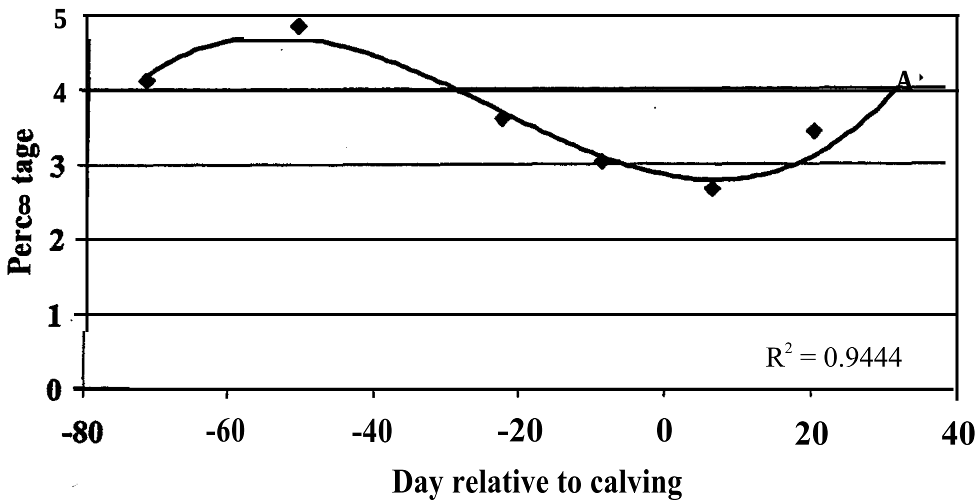
SEM = 10.9.

Figure 2. Rumen Water Holding Capacity.



*Quadratic, *P*<0.01.
SEM = 3.7.

Figure 3. Dry Matter Fill as a Percentage of Rumen Water Holding Capacity.



*Quadratic, *P*<0.01
SEM = 0.44.

Figure 4. Neutral Detergent Fiber (NDF) Intake as a Percentage of Water Holding Capacity.

PRESYNCHRONIZATION OF ESTROUS CYCLES IN DAIRY COWS BEFORE OVSYNCH + CIDR AND RESYNCHRONIZATION OF REPEAT ESTRUS USING THE CIDR[1]

S. Z. El-Zarkouny, J. A. Cartmill,
A. M. Richardson, M. A. Medina-Britos,
B. A. Hensley, and J. S. Stevenson

Summary

Postpartum anestrus is one of the major limitations to achieving acceptable pregnancy rates. The Ovsynch protocol is an excellent tool to improve reproductive efficiency of dairy cows because it can induce estrous cycles in anestrous cows. In the first experiment, administering two $PGF_{2\alpha}$ injections to lactating dairy cows 14 days apart with the second injection given 12 days before the Ovsynch protocol increased (P<0.05) pregnancy rate by 10 percentage points in cycling and noncycling cows. Inserting a progesterone-releasing insert (CIDR) for 7 days during the Ovsynch protocol did not further increase pregnancy rates. In a second experiment, a resynchronization treatment consisting of a used CIDR inserted for 7 days from days 13 to 20 after insemination increased (P<0.05) embryo survival from day 30 to 58 by 11 percentage points but failed to increase overall rate of return to estrus and conception rate at the second AI (first eligible estrus after first AI).

(Key Words: Ovsynch, Presynch, Pregnancy Rates.)

Introduction

Previous studies indicated that conception rates were increased when dairy cows began the Ovsynch protocol between days 5 and 12 of the estrous cycle. We showed that a single injection of $PGF_{2\alpha}$ given 12 days before the Ovsynch protocol improved pregnancy rates in multiple-lactation dairy cows but not in first-lactation cows. This also was confirmed by research in Florida herds where two $PGF_{2\alpha}$ injections given 14 days apart with the second injection given 12 days before the Ovsynch protocol increased pregnancy rate by 12 percentage points. The objectives of the first experiment were to determine if two Presynch injections of $PGF_{2\alpha}$ would increase pregnancy rates in cows treated with the Ovsynch protocol and whether inserting a CIDR during the Ovsynch protocol would likewise improve fertility.

Several studies indicated that luteal inadequacy during the luteal phase predisposes a greater risk for lower conception rates at the subsequent estrus. We also found that progesterone supplementation by intravaginal progesterone insert (CIDR; EAZI-breed CIDR-B insert, InterAg, Hamilton, NZ) for 7 days during the ovulation synchronization (Ovsynch) protocol increased pregnancy rates at first service and embryo survival from day 30 to day 58 of pregnancy. The objective of the second experiment was to resynchronize the first eligible estrus in previously inseminated cows of unknown pregnancy status and determine whether the used CIDR would influence AI resubmission rates, conception rate at the repeat estrus, prior established pregnancy rates, and embryo survival of previously established pregnancies.

[1]We thank Ohlde's Dairy (Linn, KS) and Meier's Dairy (Palmer, KS) for use of their dairy cows and participating in these studies and we thank the Kansas Dairy Commission for their financial support.

Procedures

In the first experiment, 630 lactating dairy cows from two cooperating herds were used. Cows were less than 40 days in milk at the start of treatments and were milked 3× daily. Cows were then assigned randomly to four treatments based on days in milk and lactation number. Estrous cycles in Groups 1 and 2 were presynchronized with two injections (25 mg) of $PGF_{2\alpha}$ 14 days apart (Presynch) with the second injection given 12 days before the start of the Ovsynch protocol. Estrous cycles in Groups 3 and 4 were not presynchronized (No Presynch). All groups of cows were treated with the Ovsynch protocol consisting of two injections of the gonadotropin-releasing hormone (GnRH; 100 μg) with a $PGF_{2\alpha}$ injection given 7 days after the first GnRH injection and 48 hr before the second GnRH injection. Cows were inseminated 16-20 hr after the second GnRH injection (timed TAI; TAI). During the Ovsynch protocol, Groups 1 and 3 were fitted with an intravaginal progesterone insert (CIDR; EAZI-breed CIDR-B insert, InterAg, Hamilton, NZ) at the time of first GnRH injection and removed 7 days later. Groups 2 and 4 received no further treatment (No CIDR).

In the second experiment, all cows of unknown pregnancy status in the first experiment were assigned randomly to two treatments. A used CIDR was inserted in the first group on day 13 after TAI for 7 days (Resynch). The second group received no further treatment (control). Cows were observed for signs of estrus for 5 days upon used CIDR removal (day 20).

Blood samples were collected prior to each hormone treatment for later determination of progesterone concentrations. Pregnancy was diagnosed by ultrasonography of uterine contents (viable embryo) at day 30 and 58 after the first insemination (TAI). Pregnancy also was confirmed by the herd veterinary practictioner.

Results and Discussion

Based on concentrations of progesterone measured in three blood samples collected prior the onset of the Ovsynch protocol, over 85% of the cows were cycling. In the first experiment, the proportion of cows with elevated progesterone concentrations (≥1 ng/mL) in their blood at the time of PGF2α injection, indicative of a functional corpus luteum, was high (91%) in the Presynch groups despite the CIDR treatment. Presynchronization with two injections of $PGF_{2\alpha}$ 14 days apart and 12 days before the Ovsynch protocol increased (P<0.05) pregnancy rates at day 30 after TAI by 10 percentage points in both cyclic and anestrous cows compared to the no Presynch cows (Table 1). Thus, a high percentage of the Presynch cows were likely in an early stage of the estrous cycle at the time of initiating the Ovsynch protocol. Treatment with CIDR for 7 days during the Ovsynch protocol decreased pregnancy rates by 5 percentage points in anestrous cows and by 9 percentage points in cyclic cows (Table 1).

In the second experiment, the Resynch treatment failed to increase both overall rate of return to estrus and conception rate at second AI (Table 2). In fact, conception rates of cows inseminated between 20 and 25 days after the TAI (0 and 5 days after removal of the used CIDR) were reduced (P<0.05) compared to controls. The used CIDR treatment did not have a detrimental effect on the pregnancies established after the TAI because pregnancy rates at day 30 after TAI were not different. In contrast, the Resynch treatment (used CIDR in place from day 13 to 20 after TAI) increased (P<0.05) embryo survival to day 58 in pregnant cows by 11 percentage points (Table 2). The increase in embryo survival to day 58 resulting from progesterone supplementation provided on days 13 to 20 might have had positive effects on the developing embryo or the uterus.

In conclusion, using two injections of $PGF_{2\alpha}$ 14 days apart and 12 days before the Ovsynch protocol improved pregnancy rates of both cyclic and anestrous cows. This protocol provides dairy producers with an excellent alternative to increase reproduction performance over what can be achieved with the traditional Ovsynch protocol alone. The CIDR treatment is not warranted under these experimental conditions. The Resynch protocol with a used CIDR for 7 days inserted on day 13 after TAI improved embryo survival in pregnant cows but did not improve AI-resubmission rate at first eligible estrus following TAI for nonpregnant cows and had a detrimental effect on conception rates of cows inseminated within 5 days after removal of the CIDR.

Table 1. Pregnancy Rates at Day 30 After Timed AI

	Treatments			
Cycling status	Presynch	No Presynch	CIDR	No CIDR
	------------------- % (no.) --------------------			
Cycling	48[a] (257)	38 (244)	39 (255)	48 (246)
Anestrus	41[a] (56)	31 (67)	33 (55)	38 (68)

[a]Different (*P*<0.05) from no Presynch within cycling status.

Table 2. Fertility Traits After Resynchronization of Repeat Estrus

	Treatments	
Cycling status	Control	Used CIDR
	------------- % (no.) --------------	
Return rate	29 (189)	32 (169)
Conception rate at the repeat estrus	27[a] (55)	15 (54)
Pregnancy rate at day 30	41 (327)	43 (297)
Embryo survival from day 30 to 58	51[a] (134)	63 (127)

[a]Different (*P*<0.05) from controls.

FERTILITY AFTER SYNCHRONIZATION OF ESTRUS IN DAIRY HEIFERS USING GnRH, $PGF_{2\alpha}$, AND PROGESTERONE (CIDR)

A. M. Richardson, B. A. Hensley, and J. S. Stevenson

Summary

Our objective was to determine fertility of heifers after synchronization of estrus using $PGF_{2\alpha}$, preceded by progesterone, GnRH, or both. Dairy heifers (n = 246) were assigned randomly to three treatments: 1) 50 μg of GnRH given 6 d before 25 mg of PGF_2 (d –1) plus a used intravaginal progesterone-releasing insert (CIDR-B; d –7 to 0; CIDR+GnRH); 2) same as CIDR+GnRH without the GnRH (CIDR); and 3) same as CIDR+GnRH without the used CIDR (GnRH). All heifers were fitted with Heat-Watch® patches and characteristics of estrus examined before AI included duration of estrus, number of standing events, and total duration of standing events. In addition, all heifers were observed visually twice daily for estrus. Rates of conception and pregnancy differed among treatments. All of the estrus-synchronization treatments produced acceptable estrus detection and pregnancy rates but the CIDR+$PGF_{2\alpha}$ treatment was most effective for improving conception and pregnancy rates.

(Key Words: Estrus, Heifers, CIDR-B, Fertility.)

Introduction

The importance of dairy heifers as future replacements has been overlooked, especially in terms of their high fertility and excellent expression of estrus relative to their lactating herd mates. Estrus can be synchronized either by shortening the luteal phase with $PGF_{2\alpha}$ or by artificially extending the luteal phase with progestins. Introduced in the early 1980's, the CIDR-B (Controlled Internal Drug Release; InterAg, Hamilton, NZ) is an intravaginal insert that provides controlled release of exogenous progesterone to cattle. The CIDR increases plasma concentrations of progesterone in ovariectomized cows. Signs of behavioral estrus and ovulation are suppressed during treatment with progesterone. Short-term treatment with the CIDR produced tight synchrony of estrus, but conception rates were variable and related to treatment duration. Pregnancy rates have been reported to range from 50 to 82%. The objectives of the present study were to determine estrual characteristics and fertility of heifers after synchronization of estrus using $PGF_{2\alpha}$ preceded by progesterone, GnRH, or both.

Procedures

Holstein heifers (n = 246) averaged 13 ± 0.1 months of age (12 to 20 months) and weighed 886 ± 4 lb (754 to 1236 lb) prior to treatment. Sixteen replications of the treatments (ranging from 6 to 29 heifers per replication) were conducted between November 1998 and August 2001.

The dairy heifers were maintained in dry lots with concrete feed aprons and fed a total mixed diet of chopped prairie or alfalfa hay, corn or milo grain, soybean meal, and minerals and vitamins to exceed NRC (1989) guidelines for growing heifers by 15% for all nutrients. Heifers were assigned randomly to three treatments (Figure 1): 1) 50 μg of GnRH (Cystorelin, Merial, Iselin, NJ) was injected i.m. (d −7), 6 d before 25 mg of $PGF_{2\alpha}$ (Lutalyse, Pharmacia Animal Health, Kalamazoo, MI) was injected i.m. on d –1, plus a used intravaginal progesterone-releasing insert (CIDR-B, InterAg, Hamilton, NZ) (d –7 to 0; CIDR + GnRH + PGF); 2) same as CIDR + GnRH + PGF without the GnRH (CIDR + PGF); and 3) same as CIDR + GnRH + PGF without the used CIDR (GnRH + PGF).

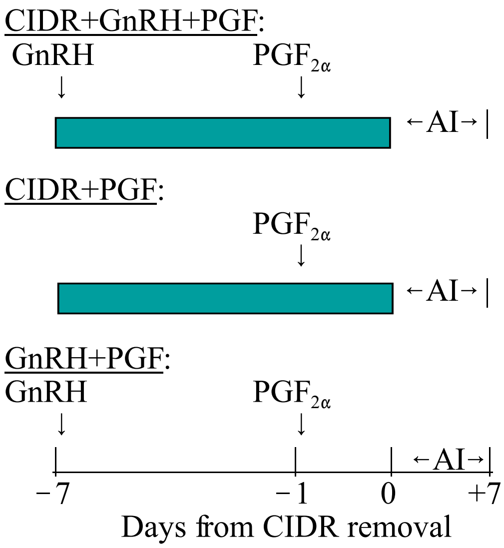


Figure 1. Experimental Protocols.

A HeatWatch® (DDX, Inc., Denver, CO) patch was attached to the rump of each heifer prior to d −7 and maintained in place until pregnancy was diagnosed. All dairy heifers also were observed visually twice daily for signs of estrus beginning on d −1. The following measurements were calculated from the HeatWatch® system: number and duration of total standing time and of each individual standing event, duration of estrus (interval between first and last standing events), and interval from the $PGF_{2\alpha}$ injection to estrus.

Interval from first standing event after $PGF_{2\alpha}$ until insemination was known in over 92% of the dairy heifers; of which over 66% were inseminated between 6 and 16 h after onset of estrus. Two technicians performed inseminations. Pregnancy was diagnosed by transrectal ultrasonography in all heifers once between 27 and 34 d after insemination.

Rates of estrus detection (number of heifers detected in estrus during 7 d after $PGF_{2\alpha}$), conception (number of pregnant heifers divided by number of heifers inseminated), and pregnancy (number of pregnant heifers after synchronized insemination divided by the number of heifers treated) were calculated. Intervals from injection of $PGF_{2\alpha}$ to visual observation or HeatWatch detection of first standing event were determined. Measures of estrus-detection rate, conception rate, pregnancy rate, interval from $PGF_{2\alpha}$ to estrus, and concentrations of progesterone were analyzed using a statistical model consisting of treatment, season, and their interaction.

Results and Discussion

Distribution of estrus after $PGF_{2\alpha}$ based on continual surveillance of the HeatWatch system for the dairy heifers is illustrated in Figure 2. More ($P<0.01$) than 60% of the heifers in the CIDR + PGF (67%) and CIDR + GnRH + PGF (75%) treatments came into estrus in the 48- to 72-h interval after $PGF_{2\alpha}$ than in the GnRH + PGF treatment (41%). However, more ($P<0.05$) heifers in the GnRH + PGF treatment came into estrus during the 24- to 48-h interval (44%) than in the other treatments (<8%).

A delayed interval to estrus after CIDR removal was explained by changes in serum concentrations of progesterone. A CIDR effect ($P<0.001$) was detected on the day of CIDR removal (day 0) where only 29% of the dairy heifers in the GnRH + PGF treatment had elevated (≥1 ng/mL) concentrations of progesterone compared to 77% of the dairy heifers in the two treatments with CIDR.

Table 1 summarizes reproductive traits of heifers in response to treatments. The estrus-detection rates varied from 73 to 85% and were not different among treatments. Conception rates varied little, from 47 to 69%, but were greater ($P<0.05$) in the CIDR+PGF treatment compared to the GnRH + PGF treatment. Likewise, pregnancy rates were greater ($P<0.05$) for heifers in the CIDR+PGF treatment.

Table 2 summarizes the estrual characteristics of the dairy heifers in each treatment. Interval from $PGF_{2\alpha}$ to estrus and the total number of standing events were affected differently by the CIDR. Interval from PGF2" to estrus was prolonged (*P*<0.001) by 18-19 hr in the two CIDR treatments compared to that for the GnRH + PGF treatment. In contrast, the pre-estrual supplementation of progesterone via the CIDR tended (*P* = 0.11) to reduce the number of standing events per estrus by 20%. Duration of standing estrus and total or individual duration of standing events were not altered by treatment.

Seasonal effects were detected for the number of standing events and duration of total and individual standing events. Total standing time was 69 to 81% greater (*P*<0.05) during spring (100 ± 16 sec) and fall (107 ± 8 sec) than during summer (59 ± 11 sec) and 51% greater (*P*<0.05) during winter (89 ± 10 sec) than summer.
These data provide evidence that administration of progesterone for 7 d before PGF2" produced superior conception and pregnancy rates. The administration of progesterone via a CIDR as described in this study has not been approved by the United States Food and Drug Administration. It is anticipated to be available within the next calendar year.

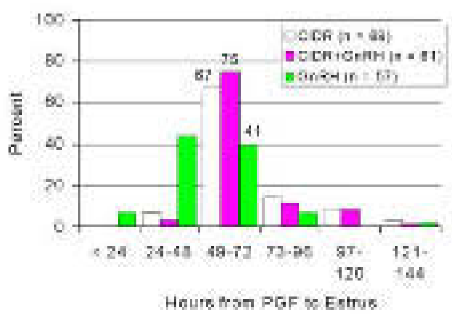


Figure 2. Percentage Distribution of Estrus after PGF2a Injection

Table 1. Estrual and Fertility Traits of Dairy Heifers after Estrus Synchronization.

	Treatments[1]		
Item	CIDR + PGF	CIDR + GnRH + PGF	GnRH + PGF
	--------------- % (no.) ---------------		
Estrus-detection rate	85.5 (83)	80.0 (80)	73.5 (83)
Conception rate[2]	69.0[a] (71)	56.3 (64)	47.5 (61)
Pregnancy rate[3]	59.0[a] (83)	45.0 (80)	34.9 (83)

[1]See Figure 1 for description of treatments.

[2]Seasonal effect (P<0.01): spring (83.3%; n = 24) vs. summer (50.0%; n = 48).
[3]Seasonal effect (P<0.01): spring (76.9%; n = 26) vs. summer (38.1%; n = 63).
[a]Different (P<0.05) from GnRH+PGF.

Table 2. Estrual Characteristics Based on the HeatWatch® System.

	Treatments[1]		
Item	CIDR + PGF	CIDR + GnRH + PGF	GnRH + PGF
No. of heifers	69	61	57
Hours from PGF to estrus	67 ± 3[a]	66 ± 3[a]	48 ± 3
Duration of estrus, h	12 ± 0.7	12 ± 0.6	11 ± 0.7
No. of standing events[2]	32 ± 4	31 ± 3	39 ± 4
Duration of standing time[2], sec	84 ± 10	81 ± 9	100 ± 11
Duration of individual standing events[3], sec	2.5 ± 0.1	2.7 ± 0.1	2.5 ± 0.1

[1]See Figure 1 for description of treatments.

[2]Summer less (P<0.05) than other seasons.
[3]Summer less (P<0.05) than autumn.
[a]Different (P<0.05) from GnRH+PGF.

MANAGEMENT OF NATURAL SERVICE BULLS ON LARGE DAIRIES

P. J. Chenoweth[1] and J. F. Smith

Summary

Natural service (NS) bulls are widely used on large dairy farms despite the well-proven genetic progress achievable through AI. Producers may choose to use NS bulls for a variety of reasons that are discussed below. In this presentation, problems encountered with the use of NS bulls on a large dairy in Kansas are described in relation to reduced reproductive performance on that dairy. Lameness in bulls was considered to be a major contributing factor to reduced herd reproductive performance, with seminal vesiculitis also possibly playing a role. Possible contributing factors for the occurrence of these problems in the bull population are discussed. A number of recommendations are made for optimal selection, use, and management of NS bulls. These include the following. Natural service bulls should preferably be younger bulls (< 2.5 years of age) and tractable. Facilities should be adequate for the safe handling of bulls and people. Attention should be paid to minimizing heat stress during the summer. An environment should be created where reproductive behavior can be fully expressed. Appropriate considerations include: sufficient space for courtship and breeding; minimizing distractions, such as people and noise; and the provision of suitable flooring for breeding (i.e., provision of secure footing). Natural service bulls should pass a breeding soundness evaluation prior to purchase and/or first use and this should be repeated at least annually. Bulls should undergo the same herd health procedures as the cow herd (except for brucella, trichomoniasis and MLV IBR vaccination). Particular attention should be paid to the prevention of venereal disease (vibriosis and trichomoniasis) transmission. Monitoring and record keeping for cows exposed to bulls should be similar to that for cows in AI groups and include regular pregnancy checks.

(Key Words: Bulls, Fertility, Lameness.)

Introduction

Bulls are commonly used on United States dairies; particularly on newly established large dairies. Natural service (NS) bulls may be exclusively employed initially, and then less as increasing emphasis is placed upon improving the herd's genetic base, including raising replacement heifers. With the latter consideration, a number of producers using NS bulls consider that they can purchase replacement heifers with acceptable genetics. Dairy bulls are often not subjected to close scrutiny or monitoring. As a consequence, many dairies fail to adequately exploit the potential for improved reproductive performance with NS bulls. NS bulls provide the "default" option when the effective implementation of AI is difficult or costly. Bulls are used in breeding management schemes to eliminate perceived obstacles to AI including costs and the lack of qualified personnel to perform tasks such as heat detection. A common perception is that a motivated bull will generally detect more heats than will humans, particularly if the latter are poorly trained. Bulls also should be able to deposit semen at the most advantageous time for female fertility because they

[1]Department of Clinical Science.

work 24 hr per day, 7 days per week . Bulls often service receptive females a number of times during the period of female receptivity. Thus, bulls continue to be used in dairy herds because they provide an alternative to managing a heat detection or an estrus synchronization program and the appropriate personnel to manage a successful AI program. This report describes problems observed with NS bulls on a large dairy in southwest Kansas.

Procedures

Bulls were examined in January 2000 on a large, newly established, 2,500-cow dairy in southwest Kansas. This was a new facility where management procedures and personnel were still evolving as the dairy grew in size and attempted to achieve production goals. All breeding was exclusively performed by NS bulls. It was evident, however, that natural breeding was not as successful as it should be, with a large number of cows (more than 500) remaining open after more than 200 DIM.

Natural service bulls were obtained under contract by a supplier and varied in age. The bull to female ratio was approximately 1:40. Female groups consisted of several hundred cows. The cow groups included varying numbers of open and pregnant females at any given time. Bulls spent much of their time in free-stalls, on concrete, although access had recently been provided to outside dirt lots. In the free-stalls, the "working" area consisted of the concrete alley-way behind the stalls, which was periodically flushed with water. Bull groups comprised mixed ages of bulls that were generally kept intact, although they were rotated between cow groups at approximately 1-week intervals. Bulls were fed the same diets as their respective cow group. Both cows and bulls were vaccinated against leptospirosis (5-way) and vibriosis. A total of 98 bulls were subjected to a physical examination, 66 of which were electro-ejaculated for semen evaluation. Approximately 30 bulls were sampled to test for trichomonosis. An additional 20 young bulls were subjected to visual appraisal only.

Results and Discussion

During examination it was observed that many of the bulls were "tentative" in their footing on concrete. Twenty-one of the 98 bulls were classified as poor breeding prospects and were recommended to be culled. An additional 7 bulls had problems that might compromise breeding success, but which could improve with time. Screening for trichomoniasis was negative for all samples. No obvious problems were detected in the young replacement bulls that were subjected to a visual appraisal only. A summation of the problems encountered in bulls is presented in Table 1.

The most common bull problem encountered was lameness. Lame bulls were recommended to be culled only if the problem was severe and probably irreversible. Lameness in the hind limbs was regarded as being more detrimental to reproductive success than lameness in the fore limbs. Severely lame bull problems included a dislocated hip, a dislocated patellar (knee cap), a number of swollen joints (particularly of the lower limbs), and acute foot soreness. Little evidence of severe laminitis was evident, although it is probable that subclinical laminitis was present. With bulls being fed the same rations as lactating dairy cows, it is probable that some bull lameness problems would be caused by excessive energy and calcium in their rations. However, it was considered that a large number of the lameness problems observed in this herd were due to trauma (i.e., loss of footing or fighting with other bulls).

The relatively high prevalence of seminal vesiculitis or accessory genital disease observed (17.3%) was of concern, although only two bulls were severely affected. Active vesiculitis will adversely affect semen quality. Often the infection will spread to other parts of the genital tract where it may lead to irreversible problems. The factors leading to increased seminal vesiculitis in a group of bulls are not all known. This problem is often encountered in young beef bulls on performance test, when there is a combination of high energy rations and intensive rearing (and perhaps increased homosexual behavior). Without further observations and tests, it would be difficult to determine the cause in this case. However, managerial options such as rotating bulls, reducing cattle density in pens, and perhaps feeding chlortetracycline should help to reduce this problem.

Conclusions

The practice of running bulls in mixed-age groups with large numbers of females in free-stalls facilities with concrete floors seems to be a major contributor to the "bull problem" encountered at this dairy. Bulls are particularly susceptible to injury during mounting and mating when they are often off-balance, with their weight being supported by the hind feet. When footing is insecure, especially in confined spaces, injuries easily occur. Bulls with injuries are less likely to mount and serve. In addition, the fear of injury will lead to loss of confidence and reduced sexual activity. In this case, running older bulls with younger bulls, particularly in confined spaces, also could contribute to lowered activity by the latter group because older bulls tend to be dominant, more aggressive, and prevent other bulls from accessing females, even if they themselves are infertile. Older bulls also pose a human safety risk as well as tending to outgrow free-stalls. In the present case, lameness also was a concern with cows at the dairy, with factors such as concrete texture and free-stall design probably playing roles.

Recommendations

The following recommendations should be followed when using bulls on commercial dairies:

- All virgin bulls should be subjected to a breeding soundness evaluation (BSE) before admittance to the herd.
- All bulls should be given a physical exam every 6 months and a full breeding soundness exam every 12 months.
- Adequate handling facilities should be provided for the working and handling of bulls to reduce the risk of injury to both animals and personnel.
- Bulls in freestall housing should be given access to dirt lots.
- All working bulls should be monitored daily.
- A workable system is to maintain bulls in breeding groups that will be rotated into the breeding herd for 1-2 weeks, followed by 1-2 weeks of rest.
- Bulls ideally should be less than 2.5 years of age. Aggressive, older and large, heavy bulls should not be sold.
- A suitable bull to female ratio is approximately 1 bull to 15-25 open cows.
- If a dairy has large pens it may be beneficial to distribute open cows over more pens to reduce the number of bulls in any given pen.
- Avoid drastic changes in diets fed to bulls. Don't put bulls abruptly onto the same diets as lactating cows without slowly increasing intake and energy in steps
- Minimize the effects of heat stress by providing shade and cooling systems.
- Bulls should be subjected to the same vaccination and preventive health program as the cows (with the exception of vaccinations for brucellosis, trichomoniasis and MLV IBR).

It is important for personnel to be especially alert for signs of lameness. Early detection of lame bulls is critical and employees should be trained to observe common lameness signs, as well as other problems associated with breeding bulls. Lame or otherwise injured bulls should be treated and/or replaced as soon as possible.

Table 1. Inventory of Diagnosed Problems of Bulls in Natural Service

Problem	% occurrence (no./98)
Lameness[1]	23 (23)
Accessory genital disease[2]	17 (17)
Penile problems[3]	7 (7)
Poor semen quality	4 (4)
Other	
Cryptorchid	1 (1)
Lumpy jaw	1 (1)
Eye cancer	1 (1)
Respiratory infection	3 (3)

[1]Severe lameness (13 of 98).

[2]Seminal vesiculitis (17 of 98).

[3]Inflammation or injury (7 of 98).

INDEX OF KEY WORDS

Indexer's note: The numbers indicate the first pages of each article that uses the listed key word.

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Hoffmann-LaRoche, Nutley, NJ
Hoogland Dairy, Maurice, IA
Hubbard Feed, Mankato, MN
InterAg, Hamilton, New Zealand
Intervet, Inc., Millsboro, DE
Iowa Limestone, Des Moines, IA
JCJ Dairy, Hanford, CA
J&M Highland Dairy, Maurice, IA
Kansas Agricultural Experiment Station, Manhattan, KS
Kansas Artificial Breeding Service Unit (KABSU), Manhattan, KS
Kansas Dairy Association, Wamego, KS
Kansas Dairy Commission, Wamego, KS
Kansas Farm Management Association, Manhattan, KS
Kansas Grain Sorghum Commission, Topeka, KS
KSU Cow Comfort Consortium (Monsanto, Hubbard Feeds, Kansas Dairy Commission, Western Dairy Management Conference, and Farmland Feeds)
Maasen Dairy, Maurice, IA
Meier Dairy of Palmer, Inc., Palmer, KS
Mellema Dairy, Visalia, CA
Merial Limited, Iselin, NJ
Miley Equipment Co., Emporia, KS
Minnesota Corn Processors, Marshall, MN
Monsanto Company, St. Louis, MO
Newkirk Dairy, Newkirk, IA
Ohlde's Dairy, Linn, KS
Pharmacia Animal Health, Kalamazoo, MI
Pioneer Hi-Bred International, Inc., Des Moines, IA
Prestressed Concrete, Inc., Newton, KS
Ronnie Strauss, Junction City, KS
Rota-Mix, Dodge City, KS
Select Sires, Plain City, OH
West Central Coop, Ralston, IA
Western Dairy Management Conference
West Agro, Inc., Kansas City, KS
Winding Meadows Dairy, Rock Valley, IA
Zinpro Corp., Eden Prairie, WI

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BIOLOGICAL VARIABILITY AND CHANCES OF ERROR

Variability among individual animals in an experiment leads to problems in interpreting the results. Although the cattle on treatment X may have produced more milk than those on treatment Y, variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

In some of the articles herein, you will see the notation "$P<0.05$". That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different", the probability is less than 5% that the difference is from chance or the probability exceeds 95% that the difference resulted from the treatment applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or -1). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as $2.5 \pm .1$. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

The Livestock & Meat Industry Council, Inc.

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